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EDITORIAL

TAPPING EXPERIMENTS ON BUDDED RUBBER TREES

This number of the Journal contains three articles from the Botanical Division on Tapping Experiments on budded rubber trees. The first by Mr. Mann contains a review of previous investigations which forms a suitable introduction to the investigations carried out by the staff of the Division.

Brief reports of the progress of these investigations have been published in the Annual Reports of the Institute for the years 1928 to 1932. A detailed account of the experiments carried out on the Pilmoor Estate clones, by Messrs. Mann, Billington and Kaimal is given in the second article "Tapping Experiments on Budded Trees on Pilmoor Estate. I". A method of test tapping of young budded trees is described and it is shewn that the system of tapping adopted is without apparent detriment to the trees. The results confirm the conclusions of previous investigators that all high yielding trees do not transmit their high-yielding properties to their vegetatively developed progeny. A few clones tested are promising.

A third article by Mr. Mann and Dr. Rhodes entitled "Tapping Experiments on Budded Rubber. II" discusses the response of different clones to tapping under a periodic system. The results show that trees of the same clones are more uniform than an average population of seedling trees, as indicated by the high degree of correlation between girth and yield and the uniformity of the dry rubber content of the latex. The results also indicate that the choice of the best tapping systems will depend on the characteristics of the clone.

Apart from the Prang Besar Estate clones, on which considerable information has been published, the Pilmoor Estate clones constitute the only suitable budded areas in Malaya on which it has been possible for the Botanical Division to continue systematic experiments over a period of years.

Since the initiation of these experiments, tapping experiments have been carried out under the supervision of or on the advice of the Botanical Division of the Institute on other clones.

Records of such investigations will be published in subsequent articles.

A bulletin is also being compiled and will be published during 1934 containing the results of investigations to date.

Our thanks are due to the Directors and Manager of Pilmoor Estate for their valuable co-operation in connection with these experiments.

Yields from Budded Trees

Enquiries are frequently received at the Institute, for information on the yields of budded rubber trees of proved clones on a commercial scale and doubt is still expressed as to the value of the records already available from the various small areas or small numbers of trees from proved clones which have been tapped over a number of years.

The fact that certain clones are no longer recommended for planting is also frequently interpreted as indicating that the budgrafting of rubber trees is not likely to be a complete success.

It has therefore been considered desirable to publish any information which is available in relation to the tapping of clones on a commercial scale.

This information is summarized by Mr. Mann in the article entitled "Notes on the Yield Performance of Budded Trees of proved Clones in commercial Practice."

The results so far obtained are very satisfactory and confirm those from the tapping of small groups of trees of the various clones previously available.

Transplanting of Budded Hevea Stumps

An article by Mr. L. E. Morris, formerly on the staff of the Botanical Division of the Institute, describes experimental work carried out at the Institute Experiment Station on the planting of budded rubber stumps with lateral roots attached and with lateral roots removed by pruning. The latter method is that normally used for the planting of stumps.

The results obtained confirm those obtained by Ostendorf in Java which are illustrated in the diagram reproduced.

The investigation shows the beneficial effect of the retention of the lateral roots in the transplanting of the stumps. The method is particularly useful for the transplanting of supplies.

Callus formation on large budded stocks

The healing of the pruned stock in budding operations is of importance in relation to the prevention of "die-back" which may have serious effects, especially in the case of the budding of large stocks 2½ to 3 years old.

Experiments have been carried out with the application, to the pruned surface of the stock, of a fungicide, an asphalt-kerosene mixture and budding wax.

All such treatments however have caused retardation in the growth of the callus tissue which forms over the pruned surface. The damaging effect of black mixtures, such as asphalt in particular, have been shown to be due to the high temperatures which result, killing the tissue beneath.

Further investigations have shown that shading of the pruned surface of the stock, without application of a fungicide or sealing mixture, has so far given the most satisfactory results.

In the investigations described by Mr. Sharp in an article entitled "Observations on the Completion of the Union in Buddings of *Hevea Brasiliensis* made on Large Stocks," the effect of the angle of cut of the pruned surface of the stock on the rate of healing is discussed. It is shown that a fairly steep angle of cut is the most satisfactory. It is also shown that the rate of healing is more rapid in the case of an untreated pruned surface than when asphalt-kerosene mixtures are applied.

On this account, it is now recommended that, in budding operations, the pruned surfaces of the stock should be cut at a fairly steep angle, in the case of large stocks and that the surface should be allowed to heal over naturally with no treatment other than partial shading from the sun.

Insecticides for the treatment of White Ants

The White Ant has been the only serious insect pest attacking rubber trees on estates in Malaya, since the plantation rubber industry came into being early in the present century.

So far no definite curative or preventive agent has been discovered, in spite of considerable investigation in Malaya and elsewhere.

In this Journal, Mr. Beeley describes investigations carried out with a number of insecticidal powders, liquid and gaseous fumigants and other methods of treatment.

It is not claimed that any method of treatment recommended is a definite immediate cure or preventative, but that systematic inspection and treatment by one or other of the methods suggested will reduce and ultimately eliminate attacks by this insect in infested areas.

In an appendix, recommendations are made for experimental work on areas in which trees are extensively attacked.

Information on the results of such investigations carried out by estate managers will be appreciated.

The Discolouration of Latex

The question of the colour of latex in its application to various industrial uses is of importance and the market is becoming more and more discriminating in respect of this characteristic. Complaints have been received from buyers from the United States of America and from Great Britain. The Institute has also been involved in considerable correspondence on the proposed inclusion of a Colour Test in a specification for latex which is under discussion in regard to its adoption by the Rubber Trade Association, London.

As a result of these complaints and also in view of the proposals submitted for a specification for latex, it will be essential to investigate certain properties of latex which may be included in any proposed specification. In addition it is important to know the cause of any variation in the quality of latex, before satisfactory recommendations can be made to eliminate or prevent the development of defects, whether these are of intrinsic importance to the manufacturers or even objections raised by dealers. In relation to colour, it has been realised that latex may be quite satisfactory before export, but may be rejected on account of colour after storage or by the time it reaches the consumer.

It was therefore essential to ascertain the cause of this development of colour on storage.

In the article entitled "The Cause of Discolouration in Preserved Latex" Dr. Rhodes describes in detail the experimental work which has been carried out to determine the cause of the discolouration and shows very definitely that this is due to contamination with iron. He also shows the changes in latex which are conducive to the acceleration in development of this colour and, apart from its prevention, indicates two methods of eliminating the colour.

Incidentally, the investigation indicates that steel drums, unless specially coated on the inside, are more liable to cause discolouration of latex than the tin coated containers which have been used by a number of estates for the export of latex. The importance of these results in relation to the problem of discolouration of latex is evident.

Quebrachitol from Latex Serum

Considerable quantities of quebrachitol from latex serum, prepared in the Chemical laboratories of the Institute, have been distributed for investigation of possible uses.

Unfortunately to date, no suitable use has been discovered for this waste or by-product. Among the possible applications, a trial of the material for treatment of diabetes has been carried out.

It is not considered necessary to publish in our Journal the detailed results of this investigation, but for purposes of permanent record, an abstract of a paper published in the Biochemical Journal in 1933 has been prepared by Dr. Rhodes and is included in this number.

Rubber and Latex Patents

In the previous number of this Journal (Vol. 5 No. 1, September 1933) a list of patents relating to rubber and latex granted or registered in the Straits Settlements and Federated Malay States was published.

In the present Journal abstracts of those specifications (prepared by Dr. Rhodes and Dr. Wiltshire) which are of general importance, particularly to producers, are published.

These abstracts refer only to patents granted in the Federated Malay States and United Kingdom or other British patents registered in the Federated Malay States.

As is stated in the introduction to the article, there are very few specifications filed in the Straits Settlements which are not included in the abstracts now published of specifications filed in the Federated Malay States.

TAPPING EXPERIMENTS ON BUDDED TREES

BY

C. E. T. MANN

Introductory Review

The first recorded experiments on the tapping of budded trees are those conducted by Grantham (1) on the Goerach Batoe Estate of the H.A.P.M. Plantations in Sumatra where, on May 2nd 1922, sixty trees of a number of clones planted in November 1918 were tapped for the first time at the age of 3½ years. A few days later tapping of budded trees on Pasir Waringin Estate in Java was commenced by Tas and Vischer (2).

The tapping experiments conducted by Vischer were preceded by careful anatomical investigations. The development of the latex vessel systems in the bark of scion and stock was carefully studied in buddings of a number of clones at 2½ years of age (3) and again at the age of 3½ years (4). Vischer found that buddings derived from the same parent tree showed striking uniformity in the development of their latex vessel systems. Later, when the results of tapping tests became available (2) it was shown that for true buddings of a single clone there exists a very close relationship between the characters of girth, yield and the number of latex vessel rows. The demonstration of these important relationships was confirmed by Grantham (1).

The budded trees on Pasir Waringin Estate were first established in August 1917 but many failures occurred in the original planting and extensive re-budding was carried out in January 1918. Unfortunately, mistakes occurred in the later budding work but it is interesting to note that Vischer's studies made it possible to distinguish those trees which were not true members of a clone.

In the following year, 1923, Heusser carried out his first tapping tests on budded trees in experimental plots established on a number of estates by the A.V.R.O.S. Proefstation in Sumatra (5). Budded trees of a number of clones, planted between January and November 1919, were first tapped during the months of January to March 1923. The first, or test-tapping, of these young trees was carried out for a period of 20 consecutive days for each clone. The trees were tapped daily with a left to right single cut at an angle of 30° over half the circumference, the lowest point of the tapping cut being 20 inches from the union. The relative growth of the budded trees of the different clones showed large differences and for some of the clones, test tapping was carried out on trees having a girth of less than 12 inches at a height of 40 inches from the union.

Test-tapping was repeated in October 1923 for a second period of 20 consecutive days. Heusser's results confirmed in striking fashion the earlier results of Vischer and Grantham. The uniformity exhibited by the buddings of single clones was again clearly demonstrated and, as a result of the very careful organisation of the experiments, no discrepancies due to mixing of material appeared to detract from the value of results.

In the same year that Heusser published his first results for Sumatra, Cramer gave a full account of his work at the Economic Botanic Garden, Buitenzorg (7).

Owing to lack of available space the experimental work of Cramer on the budding of Hevea was conducted with relatively small numbers of trees of a few clones planted in early 1918. He was enabled however, by careful intensive study of the small amount of material at his disposal, to confirm in all essentials the results recorded by Vischer, Grantham and Heusser. He also drew attention to other qualities of budded trees which had not been mentioned in the earlier studies. In tapping his buddings, Cramer adopted a somewhat arbitrary standard of "tappability." Buddings were not tapped until they had attained a minimum girth of 50 cms. (about 20 inches) at a height of 40 inches from the union. The trees were therefore better developed than many of the buddings tapped by Heusser and Grantham in their earlier experiments. Tapping was commenced in April 1923 and all buddings reaching the required standard of girth were tapped over half circumference with a left to right single cut at a height of 40 inches from the union. Subsequently, certain of the buddings were tapped at a height of 30 cms. (12 inches) from the union and, on a few trees, tapping of the stock below the union, was carried out. Comparison of buddings with seedlings was made in each case.

From the results obtained during the first year Cramer showed that, although buddings of Clone Ct. 88 may yield appreciably more latex when tapped at a height of 12 inches from the union than when tapped at 40 inches, at the same time the differences in production at the two levels are much less than the differences observed for seedlings tapped at corresponding heights. For another group of mixed buddings there was little appreciable difference between the yields obtained at a height of 40 inches and those obtained at a height of 1 inch above the point of union with the stock.

From these results it was suggested that there may be a region of optimum yield somewhere between the point of union of scion and stock and a height of 40 inches. With seedlings, the normal increase in yield with progressive lowering of the tapping cut was demonstrated.

Further important observations were made on the relationships between stock and scion. It was shown that the growth of stocks

of common seedling origin was influenced by the nature of the scion variety grafted upon them. Tapping tests carried out on the bark of stocks, below the point of union with the scion, indicated that the average yield of latex from stocks budded with high yielding scions was greater than the average yield of common seedlings, of comparable age, that had not been budded.

The first published results of tapping tests on budded trees in Malaya are those recorded by Spring (10, 11) who made observations and tests on budded trees planted on Sungei Reko Estate by Gough (12) in October and November 1921.

Tapping was commenced in August 1925 when the trees were 3½ years old; tapping was alternate daily with a left to right single cut over half circumference of the tree at a height of 20 inches from the union. The average girth of the trees tapped was over 20 inches. In June 1926 the trees were tapped with a new tapping cut over half circumference, opened at a height of 36 inches from the union on the opposite panel and further yield records were taken in August and September 1926 (11).

Comparison was made between buddings and seedlings in the experimental area and the results obtained closely confirmed those of earlier workers. Again the close relationship between girth and yield of the budded trees of the same clone was demonstrated. Although a period of only nine months separated the series of tests, a marked increase in yield was recorded in the second period, despite the fact that the tapping height was raised from 18 inches to 36 inches. Thus, the marked difference in the response of buddings and seedlings to changes in the height of the tapping cut was again illustrated.

Later developments of the work of these investigators has been discussed by Summers (8, 9) and need not be reviewed again here.

From this brief outline of the earliest investigations on the tapping of budded trees it will be appreciated that the methods employed, particularly with regard to the choice of a tapping system for budded trees, have differed widely in each investigation. Although the importance of these differences may not be great in the early stages of the work in which selection has been the main object, with increasing age of the trees there appears to have been a natural tendency to develop a tapping system for budded trees which conforms as closely as possible with the generally accepted system of tapping in force on ordinary seedling plantations in the country, or even in the district, where the experiments are in progress.

Thus, in Sumatra, Heusser (5, 6, 13, 14) has generally adopted the following scheme of tapping for the A.V.R.O.S. clones.

First tapping panel. (Test-tapping) Tapping is commenced at a height of 20 inches from the union with a left to right, single cut at an angle of 30° over half the circumference of the tree. Two

periods of test tapping, daily for 20 days at an interval of six months are followed by two to four months normal tapping, daily in alternate months, on the same panel.

Second tapping panel. Tapping is commenced at a height of 40 inches from the union with a left to right cut over half circumference. Daily tapping in alternate months is continued without rest for 3 to 3½ years. Bark consumption is controlled at 4.5 cm. per tapping month or 10.6 inches per annum.

Third tapping panel. The third tapping panel is opened at a height of 48 inches from the union, above the first or test-tapping panel, and tapping is continued daily in alternate months with a left to right single cut over one third of the circumference of the tree.

Subsequent tapping panels are opened in succession at the same height, to the left of the third panel and on one-third of the circumference of the tree.

In Java in the early years, tapping on the oldest buddings appears to have been on the same system as for ordinary seedlings. For the most part the best known clones established in Java are now tapped with a left to right single cut at an angle of 30° over one third of the circumference of the tree and tapping is alternate daily.

In Malaya, except on a very few estates, where carefully controlled experimental work is in progress, budded trees have been tapped on the particular system which happens to be in general use on the estate and the buddings have been accorded the same tapping treatment as ordinary seedlings. Generally tapping is alternate daily over half the circumference of the trees with either a single or "V" tapping cut. On estates where the careful testing of promising clones is in progress, tapping in the 4th or 5th year of age is generally confined to various systems of test-tapping with half circumference tapping cuts at a height of 20 inches. Normal alternate daily tapping over half circumference on a new panel, commencing at a height of 36 to 40 inches from the union is generally commenced in the 5th or 6th year.

In the treatment of a mixed population of trees, as represented by a normal plantation of Hevea grown from seed, for all routine operations a standard procedure must be adopted which has been shown by experience to give the best results for the field or plantation as a whole. The wide range of variation in individual tree characters makes it impossible in practice to vary any procedure sufficiently to give the best possible treatment to every individual.

In practice we are concerned primarily with the variation in the latex producing capacity of the trees and it is in relation to tapping procedure that the chief difficulties are experienced. Not only does the total production of individual trees show a wide range but there may be seasonal variations in production which differ considerably for individual trees. The existence of "periodic" yielders is well

known on estates. The properties of the latex produced from different trees may also show distinct differences.

In the selection of the best members of a seedling population as parent trees of clones, selection has been based mainly on the character of high total yield over a long period. Although the trees finally selected, and found by experiment to be satisfactory clone parents, may possess in common the desirable high yielding property they may still show considerable differences in the manner in which their high yields are attained. The yield record of one tree may show distinct periods of high yield alternating with periods of low yield whilst another may show a steady yield fluctuating but little over a long period.

Since the characters of the parent tree of a high yielding clone are to a great extent reproduced by the budded offspring it appears reasonable to expect that the yield characters of different clones will show differences comparable with those found between their respective parents. We know that, as regards vegetative characters, such differences are strongly marked; they are so clearly defined that they may be used as a reliable means of identification of different clones, and this lends support to the view that differences in the manner in which the high yield level is attained may also be encountered.

In view of these considerations it has been the aim in the present work to study the responses of different clones to different tapping methods. We have not been so much concerned with the bearing of the results obtained on the general problem of the improvement of planting material but rather with the problem of how to obtain in the most economical manner for each clone, the high yield of which we know good clones to be capable.

Brief reports of the progress of this work have been published from time to time (16, 17, 18, 19, 20) and the investigations have now reached the stage when it seems desirable to publish a full account of the results achieved.

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TAPPING EXPERIMENTS ON BUDDED TREES

EXPERIMENTS ON PILMOOR ESTATE. I

BY

C. E. T. Mann, F. Billington and K. N. Kaimal

Introduction

The experiments described in the present paper were carried out on young budded trees of a number of untested clones planted on Pilmoor Estate, Selangor, in late 1924. The history of the selection of the parent trees of these clones has been described by Sanderson and Sutcliffe (1) and details taken from the original records of budding and subsequent planting of the young budded trees are given in the present article for the sake of completeness in Table I.

The Experimental Material and Methods

The experimental plot consists of an area of approximately 8 acres of flat land cleared from virgin jungle early in 1924. Surface timber and small jungle stumps were removed and a mixed cover of *Centrosema pubescens* and *Calapogonium mucunoides* was established.

The soil is a light, quartzite loam of moderate fertility. During the first three years, drainage was not good but this was remedied in 1928 and 1929 since when, drainage conditions have been very satisfactory. A plan of the plot showing the general distribution of the experimental material is given.

Planting was commenced in November and completed in December 1924 so that when experimental tapping was commenced in January, 1928, the trees were about 3 years old, age being reckoned from the date of planting. The buddings had been made in the nursery and allowed to develop for about 9 months before transplanting. They were then pruned to a height of 18 inches and planted out in the field as "stumped" buddings. The planting distance was 20 feet by 20 feet; a plan of the plot is given in Figure 1.

Clones were planted in successive blocks or rows, an arrangement which is simple and convenient for tapping and recording but detracts from the value of the experiment as regards comparisons between different clones. However, as the conditions over the whole plot are very uniform and the differences between clones are very large the failure to plant clones in replicated plots does not seriously affect the value of the most important results.

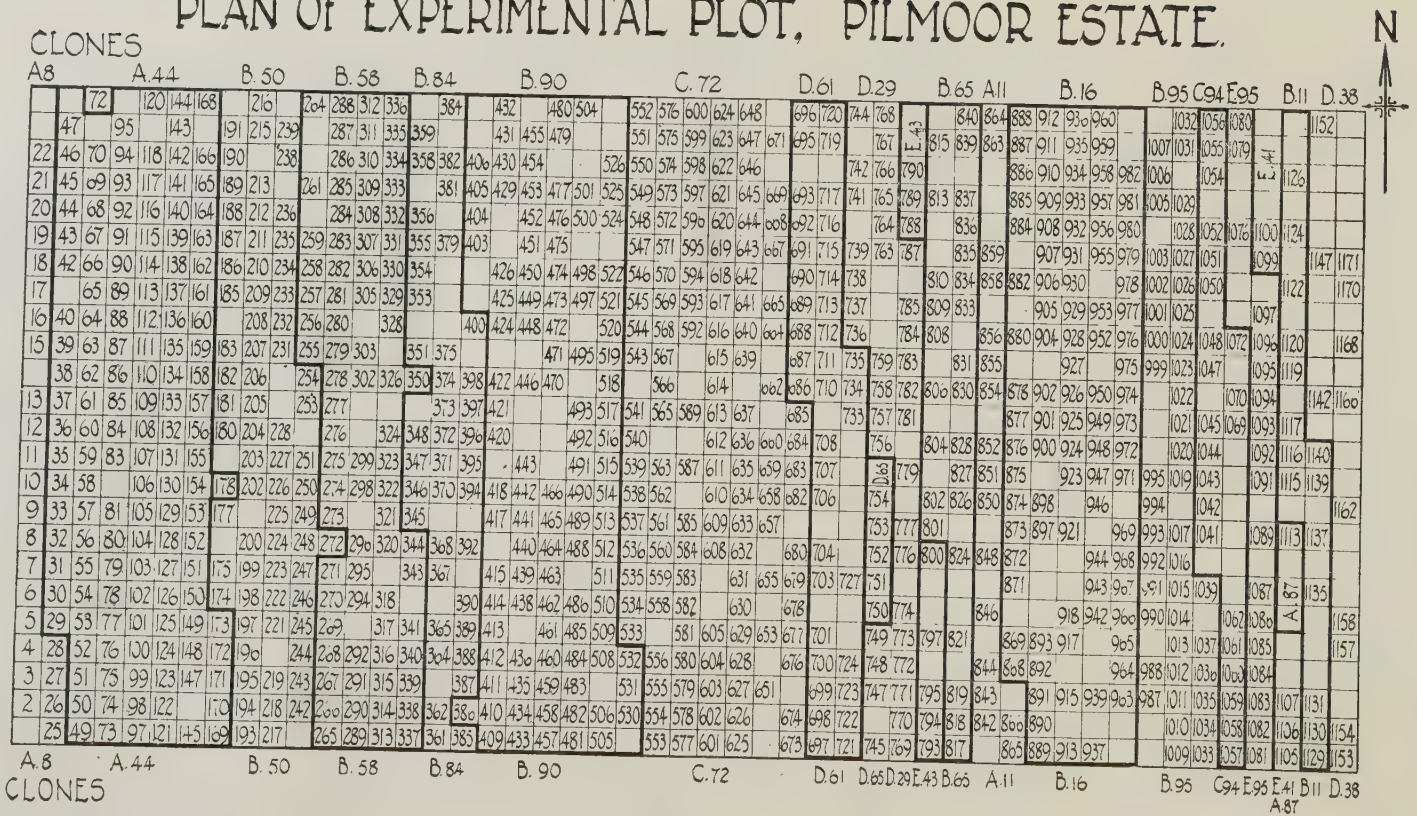

Figure 1
Plan of experimental plot showing distribution of the budded trees

The general maintenance of the area has been carried out according to normal good estate practice but during the first two years careful pruning of side branches on the young buddings did not receive sufficient attention. As a result, the plot contains a rather large proportion of trees with low branches and crooked trunks. This is especially noticeable in clone A. 44, for the buddings of this clone have a strong tendency to branch early, producing strong lateral branches one of which may replace the true terminal shoot. This branching habit can be easily controlled but, if early pruning is neglected, an irregular main trunk results. In this respect the Pilmoor clone A.44 resembles the AVROS clone 152.

In December, 1927, girth measurements were taken on all trees in the experimental area. Girth was measured at a height of 40 inches from the union. Examination of the figures showed that quite a fair proportion of the trees exceeded 15.5 inches in girth and, as this had been considered by previous workers to be a suitable standard for commencement of test-tapping, it was decided to commence tapping experiments in January, 1928. Preliminary tests showed that the tapping of trees having a girth considerably less than 15.5 inches presented no difficulty and finally all trees over 13 inches in girth at a height of 40 inches from the union were included in the tests. In Table I the numbers and percentages of tappable trees in each clone are summarised. Losses between planting and commencement of these tests are accounted for by root disease, wind damage and the growth of seedling shoots from the original stocks where the scions had failed to shoot after pruning.

Choice of Tapping System and Procedure

In view of the tender age of the trees it was considered desirable to adopt a very light tapping system and to introduce frequent rest periods between successive tests. It was therefore decided to tap alternate daily for one month (16 tappings) followed by one month of rest, and to continue the tests on the same lines so long as no ill effects on the trees became apparent.

In clone A.44, since a large number of trees was available, tapping was also carried out every third day in alternate months on a second group of trees.

Trees were marked for tapping with a single left to right cut at an angle of 30° so that the lowest point of the cut was at a height of 20 inches (50 cms.) above the union. Owing to a mistake in the instructions given for marking the trees in preparation for tapping, the original tapping cuts were all marked at a standard length of 8 inches. This length of tapping cut was exactly equivalent to half the circumference on the smallest trees but was slightly less than a half circumference cut on the largest trees. The

error was corrected during the second tapping period and subsequently all trees were tapped over half the circumference.

One Tamil tapper was employed throughout the tests. Tapping commenced at 6.15 a.m. and was completed at about 8.30 a.m. and the order of tapping was changed on each tapping day. On wet mornings the trees were tapped late so that the full number of 16 tappings was obtained in each period.

Method of Recording Yields

At each tapping, latex was coagulated in the cup with a few drops of 5 per cent. solution of acetic acid, the coagulum pressed into a rough biscuit and hung on a labelled wire hook attached to the tree. The small amounts of "cut" scrap and cup film were added to the latex at each tapping. At the end of each week samples were collected, creped separately, dried and weighed at the laboratory. Records of total yield in grams of dry rubber per tree per tapping were obtained.

Experimental Results

General Observations

The summary of results presented in Table I brings out a number of important points. The results obtained again confirm that, by vegetative propagation, it is possible to produce from certain selected parent trees buddings which are capable of giving high yields at an early age. The actual yields recorded for the most promising clones, A. 44, B.84 and B.58, compare very favourably with the yields recorded for some of the best known proved clones e.g. AVROS 49, at comparable age.

The parent trees are arranged in order of yield merit and it is at once apparent that, if they are judged on the basis of these early tapping tests on their budded offspring, the highest yielding parent trees do not necessarily give the highest yielding clones. For example, the highest yielding parent tree gave the fourth highest yielding clone, and the fourth highest parent tree gave the second best clone. Buddings from parent tree B.90 gave practically no latex during the first tapping period and, even during the second period, the flow of latex was hardly sufficient to reach the tapping cup. Yet, the parent tree gave a very good yield for a seven year old tree and was the sixth highest yielder in a group of 500 trees.

After the first tapping period the poorest clones were omitted from the tests. After the third tapping period, completed in June, tapping of clones C.72, D.29, E.95, B.95 and D.65 was discontinued. Clone C.72 was abandoned on account of the weak branching habit of the trees. Every strong wind resulted in two or three casualties

TABLE I

Records of the Parent Trees, Establishment of Buddings, and a Summary of the Results of Test Tapping of Buddings in 1928

Parent Tree	Parent trees 1922–1923 (Age 7 to 8 years)					Buddings 1928 (Age 3 to 4 years)									
	Girth in inches at height of 20 inches	Numbers of latex vessel rows at heights of:–			Mean yield in grams per tapping	Date of Budding	No. of buddings planted November to Dec. 1924	Number growing in December 1927	Number of trees tapped January 1928	Percentage of tappable trees	Summary of Records of buddings tapped in 1928				Order of Merit based on yield
		5 inches	10 inches	20 inches							Mean girth in inches at height of 40 inches December 1927	Mean girth in inches at height of 40 inches January 1929	Number of tappings	Mean yield in grams per tree per tapping in 1928	
B. 58	44	15	14	11	42.3	1924 Jan.	90	80	21	25.1	14.4	18.5	96	7.3	4
A. 44	42	...	14	12	42.1	1923 Dec.	145	133	30	22.5	14.3	18.7	96	12.5	1
C. 72	47	21	19	14	34.8	1924 Feb.	153	120	66	55.0	15.4	20.1	48	3.5	8
B. 84	41	27	21	20	28.7	,, ,,	56	40	20	50.0	15.4	20.5	96	10.8	2
A. 8	41	...	18	17	28.2	1923 Dec.	28	26	...	...		...	...	...	...
B. 90	43	20	17	16	27.3	1924 Feb.	132	105	45	42.9	15.8	21.0	...	...	...
D. 61	43	24	19	17	26.3	,, Mar.	50	35	1	2.8	15.8	20.5	96	10.4	3
D. 38	46	20	20	18	25.8	,, Jun.	36	26	...	...	...	...	...	...	...
B. 65	33	13	11	10	25.3	,, Mar.	40	27	...	...	...	...	...	...	...
D. 29	36	20	19	17	25.1	,, ,,	46	32	18	56.3	14.7	23.7	48	2.7	9
E. 95	42	31	27	20	24.5	,, May	26	15	3	20.0	15.4	21.8	48	3.6	7
B. 16	37	13	10	9	24.3	,, Apr.	116	92	...	...	...	...	...	...	...
A. 11	44	...	15	12	24.1	,, ,,	28	18	2	11.1	15.4	21.5	16	1.7	11
E. 41	44	24	24	19	23.6	,, ,,	11	7	...	...	...	...	...	...	...
B. 50	40	32	20	18	22.8	,, Jan.	81	68	17	25.0	14.1	18.9	96	5.2	5
B. 95	45	26	22	22	22.8	,, Apr.	55	45	7	15.5	14.2	20.9	48	2.1	10
C. 94	45	17	14	11	21.5	,, ,,	33	25	...	...	...	...	...	...	...
E. 43	38	19	16	13	20.4	,, Mar.	13	9	2	22.2	14.3	20.0	16	1.4	12
D. 65	33	15	13	10	17.7	,, ,,	6	5	2	40.0	15.1	18.6	48	4.7	6
A. 87	45	...	35	22	12.2	,, May	4	2	...	...	...	...	...	...	...
B. 11	44	26	21	17	10.1	,, ,,	27	15	1	6.7	16.0	21.8	16	0.2	13

and it was felt to be a waste of time to continue work on a clone possessing this undesirable weakness. Clones D.29, E.95, B.90 and B.95 were omitted on account of their low yields. Tapping of clone D.65 was discontinued on acccunt of the small number of trees available. The yields recorded for the two trees in tapping were quite good but it was considered best to run no risk of damaging the trees at this stage, in view of the fact that only five buddings were available for future work.

It must be emphasised that a reliable comparison of the clones cannot be made on the basis of these early tests. Only the largest trees of the most vigorous clones had reached the arbitrary standard of girth regarded as necessary for the initiation of test tapping. It is possible that some of the clones of less vigorous growth may prove to be as good as, or even superior to those included in the present tests. Later experiments will decide this point; in the meantime it is proposed to describe in more detail the records obtained on the most promising clones tested in this first investigation.

Records of the Yields of individual Trees of Clones A.44, B.84 and B.58

Tapping was carried out on alternate days for six periods.

1st	period	January	10th	to	February	9th	1928	...	16 tappings
2nd	,,	March	12th	,,	April	11th	,,	...	do
3rd	,,	May	12th	,,	June	11th	,,	...	do
4th	,,	July	12th	,,	August	11th	,,	...	do
5th	,,	September	12th	,,	October	12th	,,	...	do
6th	,,	November	9th	,,	December	9th	,,	...	do

Total tapping days :—96

In Table II the average yield per tree in grams of dry rubber per tapping during each period is given, together with the mean yield for each tree over the whole year. Girth measurements, taken at the beginning and again after the conclusion of the tests in January, 1929, are also given.

The figures reveal a very high degree of uniformity in the yields of the trees of the same clone; in general the largest trees of each clone are the highest producers. The actual statistics for the correlation between tree girth and yield have not been included on account of the small number of trees available in each clone. Since only the best trees of each clone could be tapped, statistical examination of the limited data from these would not give a true indication of the variation within the clone.

TABLE II

Summary of Growth and Yield Records of budded Trees of Clones A.44, B.84, and B.58.

Tapped on half circumference alternate daily with alternate monthly Periods of Tapping and Rest.

Clone	Tree Number	Girth at height of 40 inches from the union		Yield in grams dry rubber per tapping on successive monthly periods.						Average Yield per tree per tapping
		Dec. 1927 inches *cms.*	Jan. 1929 inches *cms.*	1st	2nd	3rd	4th	5th	6th	grms.
A 44	40	14.0 *35.6*	19.5 *49.5*	5.6	6.8	9.3	10.8	14.3	18.1	10.8
	109	14.0 *35.6*	18.8 *47.8*	7.4	5.9	9.9	11.9	14.3	16.5	11.0
	114	14.8 *37.6*	18.8 *47.8*	7.3	7.6	11.0	11.6	13.9	21.2	12.1
	116	15.0 *38.1*	17.5 *44.5*	14.2	13.1	17.3	19.8	22.7	26.0	18.9
	138	15.5 *39.4*	19.8 *50.3*	8.7	10.0	14.0	16.6	17.8	21.9	14.8
	156	16.3 *41.4*	18.8 47.8	10.7	9.8	13.4	16.0	18.3	20.7	14.8
	165	16.3 *41.4*	20.3 *51.6*	6.9	9.7	13.3	19.7	20.2	24.5	15.7
	168	14.8 *37.6*	20.0 *50.8*	7.6	6.3	11.2	14.5	15.9	22.7	13.0
	46	13.5 *34.3*	19.0 *48.3*	...	8.8	8.0	10.7	12.5	16.8	11.3
	87	13.5 *34.3*	17.5 *44.5*	...	9.3	8.6	10.8	13.9	15.9	11.7
	92	13.5 *34.3*	17.3 *43.9*	...	9.9	7.6	8.1	10.1	13.0	9.7
	145	13.5 *34.3*	19.5 *49.5*	...	10.4	9.6	13.1	15.8	17.6	13.3
	148	13.5 *34.3*	18.8 *47.8*	...	10.6	13.0	12.7	15.7	18.3	14.1
	160	13.3 *33.8*	17.0 *43.2*	...	8.1	7.5	10.5	11.0	13.6	10.2
	172	13.2 *33.5*	17.5 *44.5*	...	6.4	7.0	7.9	11.4	12.7	9.1
Mean	15 trees	**14.3** ***36.3***	**18.7** ***47.5***	**8.6**	**8.8**	**10.7**	**13.0**	**15.2**	**18.6**	**12.7**

TABLE II—*(Continued)*

Clone	Tree Number	Girth at height of 40 inches from the union		Yield in grams dry rubber per tapping in successive monthly periods						Average yield per tree per tapping
		Dec. 1927 inches *cms.*	Jan. 1929 inches *cms.*	1st	2nd	3rd	4th	5th	6th	grms.
B. 84	346	16.0 *40.6*	21.2 *53.8*	2.3	7.0	8.4	10.6	13.2	23.2	10.8
	351	15.3 *38.9*	21.5 *54.6*	4.0	7.3	11.2	10.5	12.9	21.1	11.2
	353	16.0 *40.6*	21.3 *54.1*	2.2	6.1	8.9	12.5	11.4	20.3	10.2
	354	14.0 *35.6*	19.7 *50.0*	3.0	7.6	10.0	10.8	11.3	15.7	9.7
	355	17.0 *43.2*	21.0 *53.3*	2.7	7.7	11.3	13.8	15.6	20.9	12.0
	356	16.8 *42.7*	21.0 *53.3*	3.2	5.6	9.5	12.5	15.4	20.9	11.2
	358	15.8 *40.1*	20.0 *50.8*	3.9	8.4	8.5	13.9	14.7	20.6	11.7
	363	14.8 *37.6*	19.5 *49.5*	2.0	4.9	6.6	11.5	14.7	25.3	10.8
	368	15.8 *0.41*	20.3 *51.6*	2.3	5.2	8.4	12.8	14.1	21.7	10·8
	370	14.3 *36.3*	19.3 *49.0*	2.6	8.6	7.4	10.7	13.1	21.0	10.6
	374	16.5 *41.9*	21.5 *54.6*	3.2	6.5	9 8	10.9	12.4	17.8	10.1
	379	17.8 *45.2*	23.0 *58.4*	2.8	8.3	10.6	13.9	12.9	22.0	11.8
	382	19.0 *48.3*	27.5 *69.9*	2.4	6.2	7.6	12.5	13.8	18.7	10.2
	392	16.5 *41.9*	21.5 *54.6*	2.2	8.2	13.6	16.9	19.4	36.3	16.1
	397	14.5 *36.8*	19.0 *48.3*	2.8	7 6	10.6	12.7	13.9	22.6	11.7
	347	13.3 *33.8*	18.0 *45.7*	...	7.1	9.4	13.8	14.6	21.8	13.3
	364	13.8 *35.3*	18.8 *47.8*	...	5.9	7.2	11.1	13.3	18.2	11.1
	375	13.0 *33.0*	17.7 *45.9*	...	5.4	7.2	10.9	14.0	21.1	11.7
	381	13.8 *35.3*	19.0 *48.3*	...	3.5	6.0	8.6	10.5	14.6	8.6
	390	13.3 *33.8*	18.3 *47.5*	...	4.3	6.7	8.6	10.5	15.9	9.2
Mean	**20 trees**	**15.4** ***39.1***	**20.5** ***52.1***	**2.8**	**6.6**	**8.9**	**12.0**	**13.6**	**21.0**	**11.1**

TABLE II —*(Continued)*

Clone	Tree Number	Girth at height of 40 inches from the union		Yield in grams dry rubber per tapping in successive monthly periods						Average Yield per tree per tapping
		Dec. 1927 inches *cms.*	Jan. 1927 inches *cms.*	1st	2nd	3rd	4th	5th	6th	grms.
B. 58		15.3	18.3							
	257	*38.9*	*47.5*	1.9	7.2	5.9	5.5	6.7	13.1	6.7
		15.8	19.2							
	265	*40.1*	*48.8*	3.0	8.3	9.2	8.4	8.7	20.4	9.7
		14.3	18.0							
	272	*36.3*	*45.7*	2.8	6.0	6.3	7.3	7.3	12.4	7.0
		16.8	22.7							
	275	*42.7*	*57.7*	2.5	5.7	7.8	10.1	12.1	22.9	10.2
		15.3	18.3							
	276	*38.9*	*47.5*	2.4	6.8	5.8	4.7	5.4	14.0	6.5
		14.3	16.5							
	282	*36.3*	*41.9*	1.9	5.2	4.8	3.4	5.6	14.6	5.9
		14.5	18.6							
	287	*36.8*	*47.2*	2.2	5.6	7.1	7.7	9.2	19.8	6.6
		14.0	19.0							
	295	*35.6*	*48.3*	2.2	5.3	5.3	6.5	8.6	19.5	7.9
		14.3	18.0							
	311	*36.3*	*45.7*	2.0	4.5	5.3	5.8	8.9	21.9	8.1
		14.0	18.0							
	317	*35.6*	*45.7*	1.5	4.3	3.0	4.8	5.5	12.9	5.3
		15.5	20.2							
	324	*39.4*	*51.3*	1.9	4.4	5.8	6.9	6.7	17.1	7.1
		15.0	19.0							
	333	*38.1*	*48.3*	1.7	5.4	5.1	5.5	6.3	15.4	6.6
		14.0	18.0							
	335	*35.6*	*45.7*	2.5	6.8	5.5	4.6	8.6	16.6	7.4
		14.5	18.3							
	340	*36.8*	*47.5*	3.1	6.8	6.8	8.8	12.2	21.4	9.9
		13.8	18.0							
	269	*35.3*	*45.6*	...	3.1	3.5	3.4	4.9	12.2	5.4
		13.8	18.7							
	278	*35.3*	*47.5*	...	4.7	4.6	4.6	5.6	14.6	6.8
		13.5	17.0							
	279	*34.3*	*43.2*	...	4.8	5.9	4.9	5.6	13.6	6.4
		13.3	17.5							
	286	*33.8*	*14.5*	...	2.3	3.8	4.4	5.3	9.6	5.1
		13.5	19.0							
	291	*34.3*	*48.3*	...	7.3	9.5	8.4	14.2	26.0	13.1
		13.5	18.0							
	315	*34.3*	*45.7*	...	3.9	5.7	6.8	9.4	17.5	8.7
		13.0	17.5							
	331	*33.0*	*44.5*	...	3.4	4.2	4.9	5.5	13.7	6.3
Mean	**21 trees**	**14.4**	**18.5**	**2.3**	**5.3**	**5.6**	**6.1**	**7.7**	**16.6**	**7.3**
		36.6	***47.0***							

TABLE III

Mean Yield per Tree on successive tapping Days

(Each figure is a mean of six records)

CLONE	Yield in grams of dry rubber per tree per tapping															Mean yield in grams per tapping
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
A. 44	6.2	9.0	11.6	12.7	**16.0**	15.8	15.7	14.8	13.6	13.3	12.5	12.7	11.7	11.8	11.1	11.3	**12.5**
B. 84	4.8	7.6	10.9	11.2	13.0	13.1	**13.2**	11.7	11.4	11.6	10.7	11.1	10.7	10.5	9.9	10.6	**10.8**
B. 58	2.4	4.4	5.6	6.1	8.7	**9.7**	9.4	8.7	8.0	8.2	7.6	8.0	7.7	7.8	7.8	8.1	**7.4**

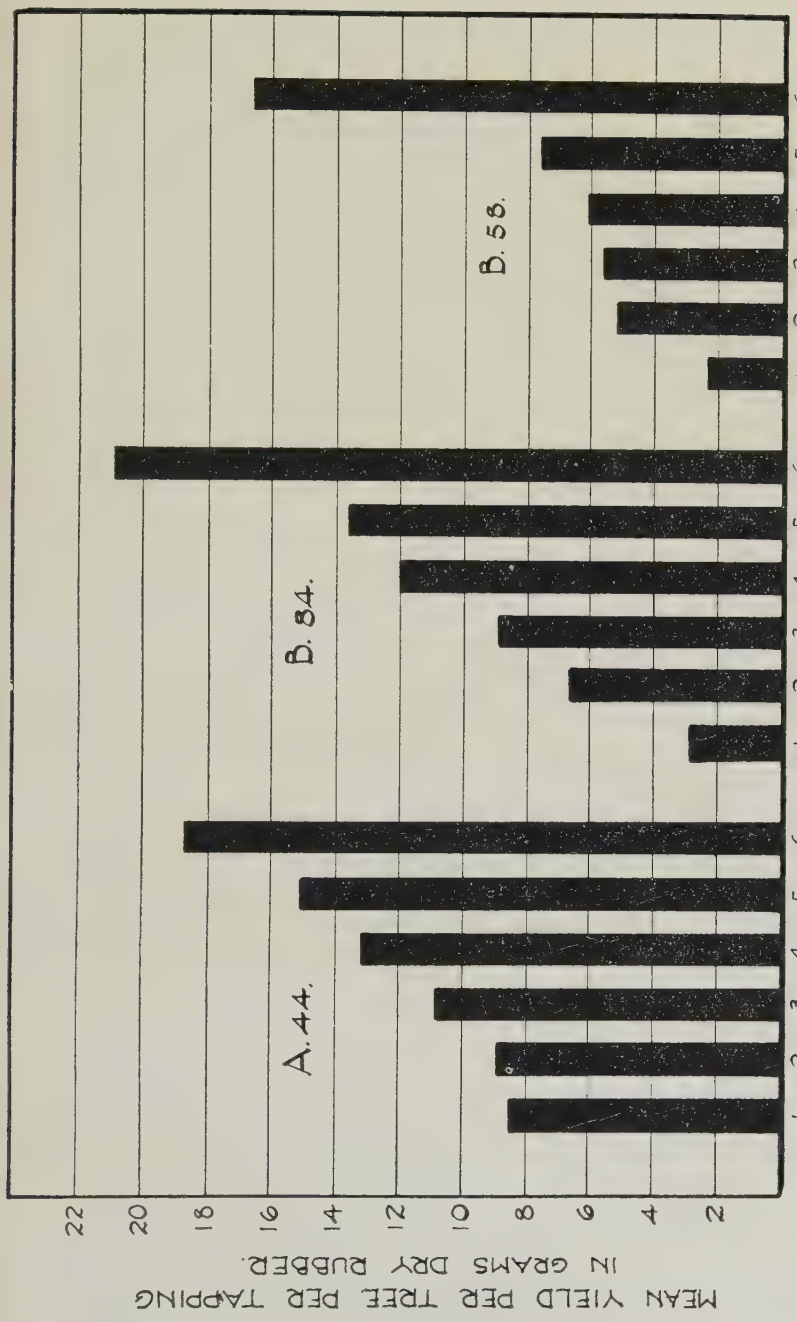

FIGURE 2

Illustrating the progressive increase in yield of Clones A.44, B.84 and B.58

Comparison of the Responses of different Clones to the same Tapping System

The initial high yield of Clone A.44 in the first tapping period in comparison with the yields of Clones B.84 and B.58 is noteworthy. It seems that clone A.44 responds much more rapidly than either of the other clones to the stimulus of tapping. Incidentally the records show how misleading the results of a short period of test tapping may be in judging the relative values of clones at an early age.

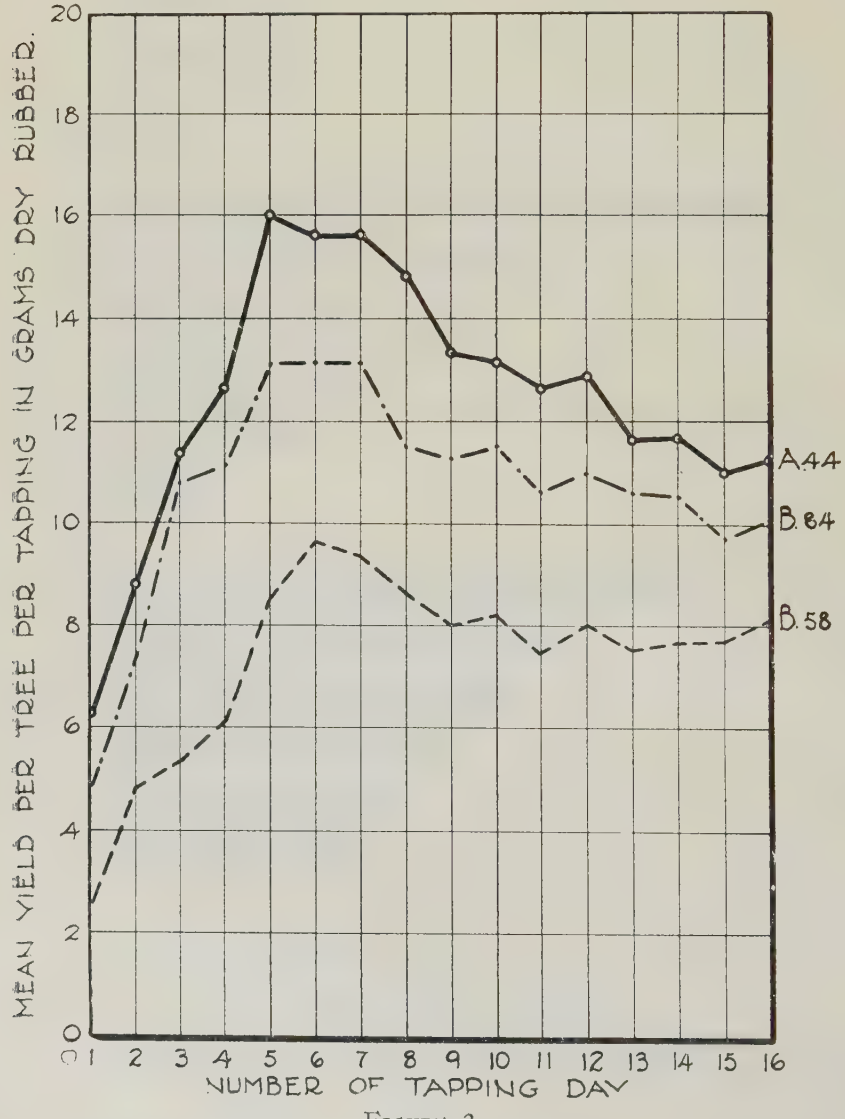

Figure 3
Illustrating the course of yield increase during an average tapping period

The rates of increase in yield of the three clones are illustrated graphically in Figure 2.

The response to tapping is further examined in more detail from the daily records of yield in the six periods of test-tapping. For each clone the mean daily yield per tree on the first, second and successive tapping days has been calculated. The results are presented in Table III and illustrated in Figure 3.

The yield of clone A.44 rises to a sharp maximum value about the 5th day and then falls somewhat rapidly to a minimum value on the 15th day. In clones B.84 and B.58 the yield rises much more gradually to a maximum value on the 6th or 7th day and thereafter the decline in yield is much less rapid than in clone A.44. These differences between the clones in response to tapping have been further investigated in a later experiment and will be discussed in more detail in the next paper of this series. Holder and Heusser have shown a similar variation in response of different clones to a uniform tapping system. (2)

Third daily Tapping in alternate Months

When these experiments were started the influence of tapping at a very early age on the behaviour of the trees was not known and a lighter tapping system was therefore tested for comparison with the general system of alternate daily tapping in alternate months. Unfortunately, only in clone A.44 were sufficient trees available for this test but the results given in Table IV are of interest.

TABLE IV

Comparison between the Results of Test Tapping on Clone A.44

(a) Alternate daily in alternate months

(b) Third daily in alternate months

Tapping system	No. of trees	Girth at height of 40 inches from union		Yield in grams of dry rubber per tapping in comparable periods					Mean yield per tree per tapping (grams)
		Dec. 1927 (inches) (cms)	Jan. 1929 (inches) (cms)	1st	2nd	3rd	4th	5th	
(a) Alternate daily	15	14.3 *36.3*	18.7 *47.5*	8.8	10.7	13.0	15.0	18.6	13.2
(b) 3rd daily	15	14.2 *36.1*	18.6 *47.2*	7.0	10.1	12.4	15.5	21.8	13.4

There is close agreement between the two series of records presented in Table IV, yet the trees in group (a) tapped alternate daily, received 80 tappings whilst those in group (b) tapped third daily, received only 55 tappings. The total weight of rubber harvested from the two groups of trees was almost exactly proportional to the number of tapping days. Had the alternate daily tapping system been too severe, one would expect a lower average yield from the trees that were being too severely taxed. That no evidence of this is found in the results obtained on clone A.44 suggests that tapping of young budded trees from 3 to 4 years of age on an alternate daily alternate monthly system can be undertaken without detriment to the trees. During the period of test the average girth of the trees increased from 14.3 to 18.7 inches and a similar satisfactory rate of growth was recorded in the other clones tapped (see Table I). Not a single tree showed any signs of brown bast during the whole period of the tests. At the conclusion of the tests an examination of virgin and renewed bark was made on the trees which had been test-tapped. The results of this examination, which have already been reported (3), showed bark renewal, in the early stages, to be very satisfactory.

Notes on the Characters of Individual Clones

Clone A.44

Growth of the trees is moderately vigorous. The main trunks require careful pruning when young, otherwise ugly irregularities may develop. Branching is strong, the lateral branches making a wide angle with the trunk. The crown is globular being built up of a large number of spreading branches of equal strength. The bark is smooth and greyish and shows rather pronounced swellings near the dormant buds. Though the yield of this clone in the test tapping period was extremely good, the vegetative characters are not pleasing.

Clone B.58

Growth is less robust than in any other clone in the experimental block but the buddings appear perfectly healthy. Trunks are erect and slender, branches are strong and well spaced, forming a conical well-shaped crown. The bark is rough and grey-brown in colour.

Clone B.84

This is one of the most vigorous clones in the collection and one of the most attractive in appearance. Trunks are strong and erect; the union with the stock is very smooth and, as the bark is deep brown, rough and considerably more corky than is usual in

budded trees, it is sometimes difficult to distinguish a budding of this clone from a well grown seedling tree. Branches are very strong and slightly spreading, forming a somewhat heavy crown.

Clone D.61

Only one tree of this clone was tapped but since this tree gave a very satisfactory yield it may be of interest to give further details. The parent tree of this clone was chosen as a brown bast subject with a high yield. The buddings are not attractive trees and already the trunks of most of the trees show signs of burr development. The high yield, provided that later tests confirm the results of the early tapping, is about the only good character which this clone possesses.

Clone D.65

The five buddings of this clone are remarkably uniform in appearance. Trunks are erect and sparsely branched. Bark is smooth and greyish. In general form the buddings are very similar in appearance to those of clone AVROS 50.

The remaining clones, since they do not appear to possess the necessary high yielding characters, do not merit detailed description at this stage.

Summary

1. A method of test-tapping of young budded trees from 3 to 4 years of age is described.

2. It is shown that young buddings, having reached a certain stage of development, indicated by a minimum girth of 13 inches at a height of 40 inches from the union, can be tapped for the purpose of selection, on an alternate daily alternate monthly system for one year without any apparent detriment to their health and vigour of growth.

3. The results of early tapping tests indicate that the yield of a parent tree cannot be taken as a reliable criterion of its value as a clone parent. From a group of 19 trees selected from a population of 500 only four have given buddings which appear to possess the desirable high yielding characters of their parents, at least at an early age.

4. Clones A.44, B.84, B.58 and D.65 appear promising.

5. The responses of different clones to the same tapping system may show considerable variation.

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Archief v.d. Rubbercultuur **12**, 25-49, 1928.

3. Billington F.
Observations on bark thickness and renewal in Malayan buddings.
Journal R.R.I. of Malaya **1**, 125-131, 1929.

PLATE I

Clone A.44. Budded tree at the age of 3 years 4 months.

PLATE II

Clone B.84. Budded tree at the age of 3 years 3 months—Note low branching habit which must be corrected by early pruning.

PLATE III

Clone B.58. Young budding age 3 years 4 months—Erect branching habit with well formed conical crown.

TAPPING EXPERIMENTS ON BUDDED TREES

EXPERIMENTS ON PILMOOR ESTATE. II

BY

E. Rhodes and C. E. T. Mann

Introduction

Following upon the preliminary tapping experiments carried out on the budded trees on Pilmoor Estate and described in the first paper of this series (6), the present investigation was commenced in June 1928.

Previous work by Holder and Heusser (5) in Sumatra had shown that all clones do not respond in the same way to a uniform tapping system. The tapping system employed in their work was a periodic system, the trees being tapped daily in alternate months.

In the present investigation the aims have been,

(i) to study the yield performance of young budded trees of a number of clones, using a periodic system of tapping,

(ii) to examine the variability encountered within a clone and also to examine essential points of difference between clones.

Experimental Material and Methods

The material employed in the present work consisted of 224 trees of 15 different clones. For most of the clones the largest trees were already being used in the test tapping experiments described in the second paper of this series (6). The trees used in the present work did not reach the standard of girth required for inclusion in the test tapping experiments commenced in January 1928, but had developed sufficiently by June 1928 to be brought into tapping. The actual yields recorded do not therefore represent the true performance of the majority of the clones.

The trees were 3 years and 8 months old from the time of planting as "stumped" buddings. The number of trees in each clone is given in Table II.

Method of Experiment

All trees were tapped with a left to right single cut at an angle of 30 degrees over half the circumference, commencing at a height of 20 inches above the union. Tapping was carried out daily in three

periods each of 25 days with alternate resting periods of 36 days. One tapper only was employed and the order of tapping was varied from time to time. Ordinarily tapping was completed before 9 a.m.; on wet mornings tapping was delayed until the trees were dry.

Individual tree yields were recorded in cubic-centimetres of latex. After measurement, the latex was washed back into the tapping cup and coagulated with a few drops of acetic acid. The coagulum was pressed by hand into the form of a biscuit and threaded upon a numbered wire hook attached to the tree. Scrap was collected separately.

At intervals of 6 days, samples were collected, crêped and numbered. After drying for 20 days the crêped samples were weighed.

Records

The following individual tree records were taken.

(i) Tree girth in cm. at a height of 50 cm. from the union,
(ii) Volume of latex in cc. per tapping,
(iii) Weight in gm. dry rubber per tree per tapping, excluding scrap. Owing to the difficulty of measuring very small volumes of latex accurately in the field these figures must be regarded as approximate only.
From (ii) and (iii) the dry rubber content of the latex was calculated.
(iv) Total dry rubber per tree per tapping inclusive of scrap.
(v) Bark consumption in cm. per tapping period,
(vi) Rate of bark renewal (taken in June 1929).

Rainfall records over the whole period were supplied by the estate.

Experimental Results

As the work progressed, attention was concentrated on the most promising clones. For the less promising clones no volume records were taken. Clone B. 90 was discarded after the first tapping period.

Detailed records for the best six clones are presented in Table I which is given as an appendix to the present paper, and a summary of the records of all the clones is given in Table II.

TABLE II

Summary of the yield records of the different clones (in order of yield merit) expressed as the mean daily yield per tree

Order of yield merit	Clone		JUNE—JULY				AUGUST—SEPTEMBER				OCTOBER—NOVEMBER				Mean daily yield per tree for the three periods			
	No.	No. of Trees	Vol. Latex c.c.	Dry Rubber (excluding scrap) gm.	Dry Rubber Content per cent.	Total Dry Rubber gm.	Vol. Latex cc.	Dry Rubber (excluding scrap) gm.	Dry Rubber Content per cent.	Total Dry Rubber gm.	Vol. Latex cc.	Dry Rubber (excluding scrap) gm.	Dry Rubber Content per cent.	Total Dry Rubber gm.	Vol. Latex cc.	Dry Rubber (excluding scrap) gm.	Dry Rubber Content per cent.	Total Dry Rubber gm.
1	B. 84	10	17.3	5.32	30.8	5.43	22.8	7.24	31.8	7.43	31.7	9.76	29.7	10.03	23.4	7.44	30.7	7.63
2	A. 44	40	26.9	6.77	25.2	6.87	19.4	6.46	33.3	6.65	27.4	8.7	31.4	9.07	24.5	7.32	29.5	7.53
3	D. 61	10	16.5	5.60	34.3	5.85	16.7	6.79	40.7	7.04	24.5	9.04	35.6	9.41	18.8	7.16	36.8	7.43
4	B. 16	13	15.3	4.93	32.2	5.11	15.6	5.90	37.7	6.20	20.4	7.79	37.7	8.09	16.9	6.20	35.9	6.43
5	B. 58	30	12.5	4.32	34.7	4.39	13.1	4.95	37.8	5.07	22.3	7.74	32.6	7.95	15.5	5.67	34.8	5.81
6	B. 65	8	8.3	3.34	40.3	3.61	9.2	4.09	44.4	4.37	14.5	5.32	37.2	5.62	10.4	4.25	40.4	4.53
7	A. 8	5	14.7	4.08	27.8	4.20	9.7	3.21	33.2	3.52	15.0	4.94	32.1	5.29	13.0	4.08	30.7	4.34
8	A. 11	10	...	...	...	2.97	...	...	...	3.36	...	...	...	4.79	...	...	...	3.70
9	C. 72	23	...	...	...	3.53	...	...	...	3.49	...	...	...	4.06	...	...	...	3.66
10	D. 29	8	...	...	...	2.54	...	...	...	2.93	...	...	...	4.42	...	...	...	3.30
11	E. 95	5	...	...	...	2.42	...	...	...	3.21	...	...	...	4.01	...	...	...	3.20
12	B. 50	22	...	...	...	2.30	...	...	...	1.98	...	...	...	3.46	...	...	...	2.52
13	B. 95	8	...	...	...	1.83	...	...		2.36	...	...	...	3.10	...	...	...	2.42
14	B. 11	9	...	...	...	0.92	...	...	...	1.11	...	...	...	1.82	...	...	...	1.28
15	B. 90	23	...	...	...	0.54	...	...	...	N.T.	...	...	...	N.T.	...	...	...	...

From the results summarised in Tables I and II, a general comparison of the yield performance of the clones can be made.

The order of merit of the clones, based on mean daily yield per tree in the three tapping periods, is not constant. Clones A. 44 and A.8 especially show a decided fall in yield in the second tapping period. This fall is more marked in respect of the amount of latex produced than in the actual quantity of dry rubber. The trees of both these clones are established in the most exposed portion of the experimental area where, although the surface soil is of a loose sandy texture, the area is liable to severe water logging during heavy rains.

The quality of the latex from different clones may vary within wide limits, as indicated in the differences in dry rubber content from the first to the last day of a tapping period (Table I) or from month to month (Table II).

The appreciable differences in the mean dry rubber content of the latex from different clones (Table II) appear to indicate that the quality of the latex may be a distinctive character of a clone.

These general points are illustrated in Figures 3 to 6 which have been prepared from the data contained in Table I.

Variation Within a Clone and Differences between Clones

Earlier work has demonstrated that budded trees of the same clone exhibit a much greater degree of uniformity than is shown by an ordinary population of seedling trees (2 & 8). This is readily apparent from the habit and general appearance of the trees, but it has also been found that the relationship which exists between yield and easily measurable characters such as girth, bark thickness and number of latex vessel rows in the bark, is very much closer in budded trees of the same clone than in seedlings.

The practical application of this property of a clone in relation to thinning operations in budded areas should prove of great importance, since it would mean that the smallest trees of any clone could be removed with a reasonable degree of assurance that, in so doing, the lowest yielding trees were being eliminated.

Since detailed individual tree records are available in the present work it is possible to examine the relationship between yield and certain easily measured characters.

The Relationship between tree Girth and Yield within a Clone

The statistics for variation in girth, the variation in yield and the relationship between girth and yield have been worked out in detail for clones A.44 and B.58 since, for these clones, sufficiently large numbers of trees were under observation and test.

TABLE III

Variation in tree girth, average tree yield and the correlation between girth and yield within a clone

Clone	No. of Trees	Mean Girth cm.	Standard Deviation	Coefficient of Variability	Mean yield gm.	Standard Deviation	Coefficient of Variability	Coefficient of correlation girth and yield
A. 44	40	38.3	±2.00	5.22	183	±34.9	19.08	+0.68
B. 58	30	38.8	±1.78	4.59	142	±28.68	20.20	+0.62

From the data given above it will be noted that the variation in girth is relatively smaller than the variation in yield. The coefficient of variability $\frac{(\text{Standard Deviation} \times 100)}{\text{Mean}}$ for girth is 5.22 for clone A. 44, and 4.59 for clone B. 58, while the corresponding statistics for yield have values of 19.08 and 20.20 respectively. If the relationship between girth and yield were perfect, the values of the coefficients of variability for girth and yield should be the same. The actual relationship is expressed by the coefficient of correlation which has a value of +0.68 for clone A. 44 and +0.62 for clone B. 58. It may be assumed that the degree of correlation between girth and yield, although not perfect, is highly significant and is very much greater than in the case of seedlings.

Changes in Daily Yield

Reference to Tables I and Figures 3 to 6 shows the relative changes in the yield of latex, and total dry rubber and the fluctuation in the dry rubber content of the latex for successive days of a tapping period.

Weather conditions, especially rain, naturally have a marked influence on the daily yield. Rain in the early morning, necessitating late tapping, is reflected in a pronounced decrease in the volume of latex obtained, but the dry rubber content of the latex showed a marked increase. The decrease in the actual yield of dry rubber was therefore not so great as the contents of the tapping cups appeared to indicate. When rain fell after collection there was a considerable increase in the volume of latex obtained on the following day, but the concentration of the latex was below normal. The fluctuations in daily yield of latex are therefore much more pronounced than the corresponding changes in the actual yield of dry rubber.

In order to smooth out the irregularities due to weather conditions the records for corresponding days of the three tapping periods

have been averaged (Table I) and the results are represented graphically in Figures 3 to 6.

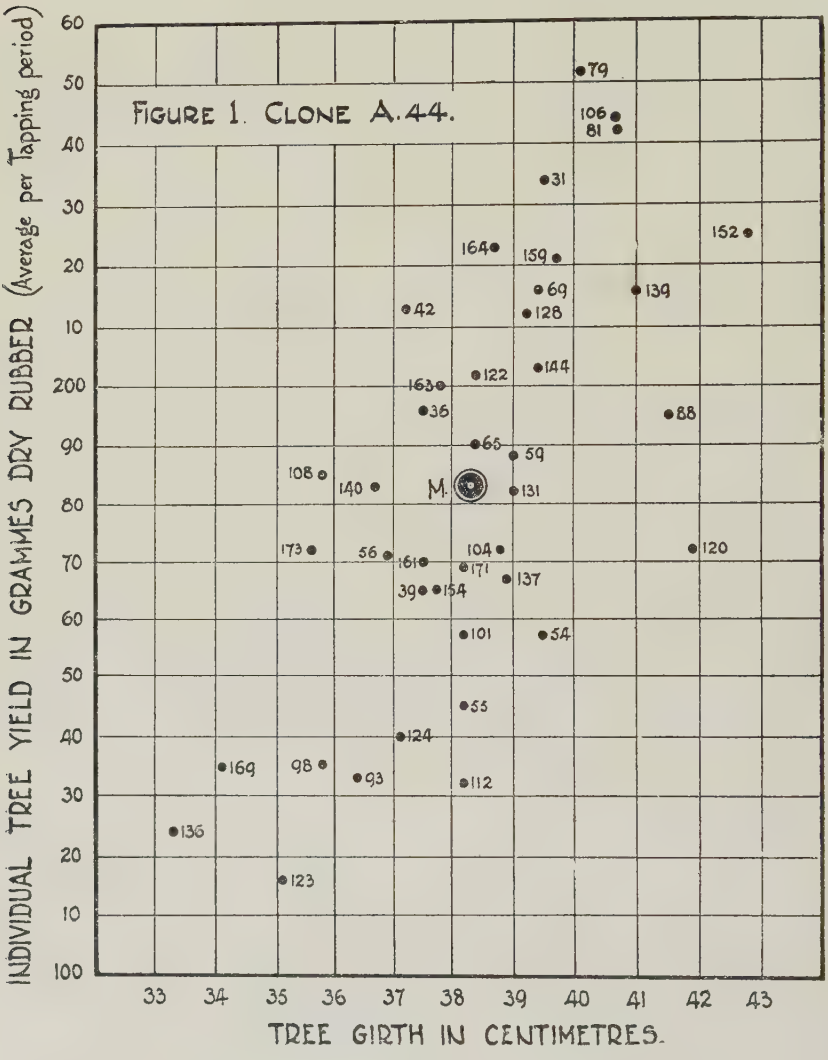


Figure 1—Illustrating the relationship between girth and yield in Clone A. 44

(a) *Yield of Latex*

The figures show that the maximum yield of latex is obtained about the 12th day of tapping in clones A. 44, B. 84, and B. 58. In all three clones there is a noticeable increase in the yield of latex about the 20th day, but in this connexion it is significant that the most frequent afternoon rains occurred in the latter half of each

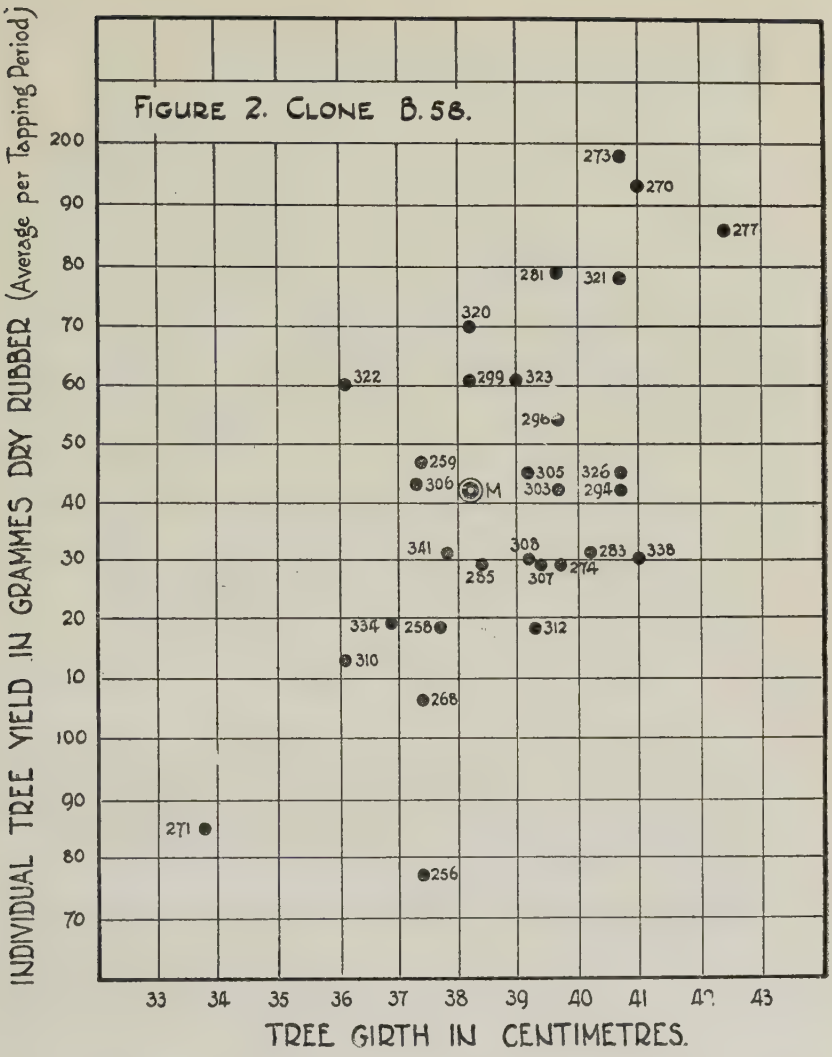
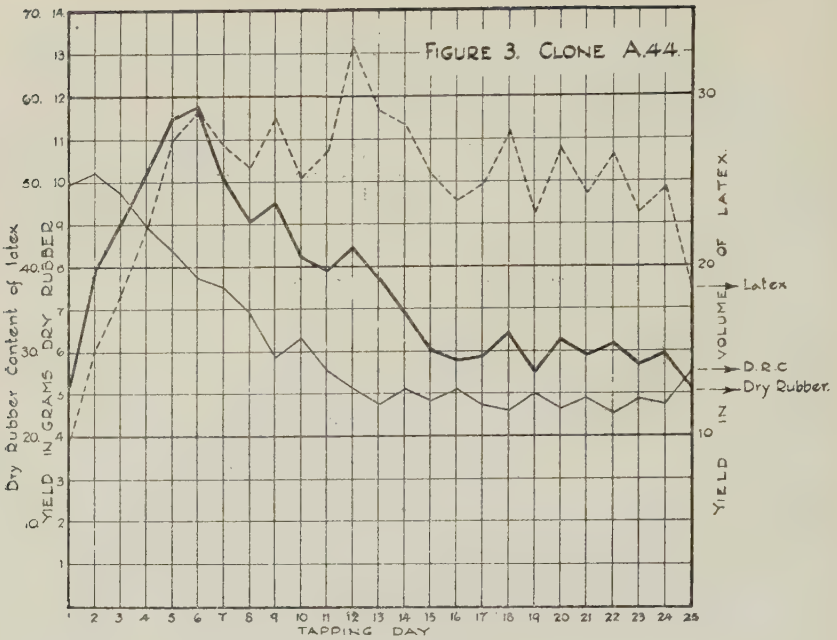


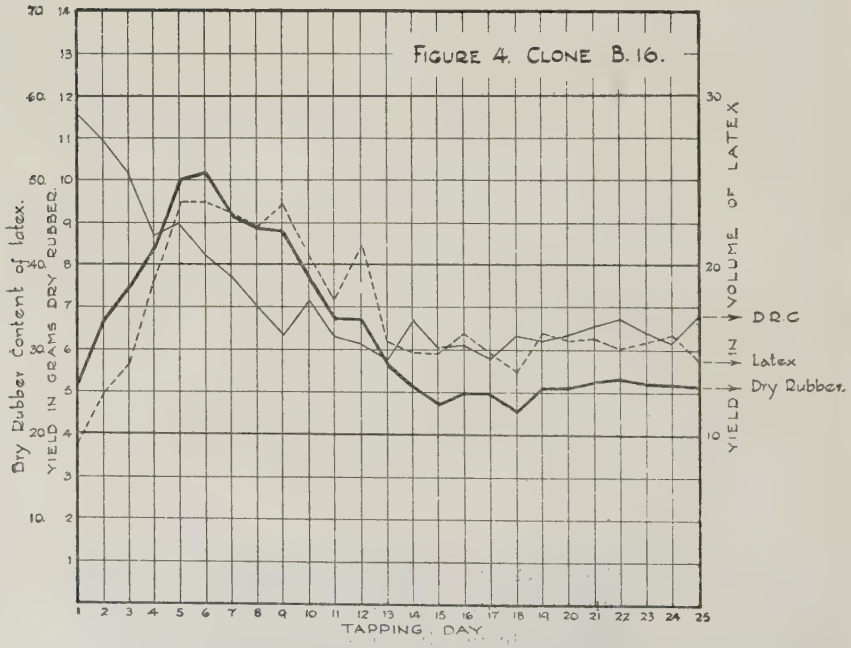
Figure 2—Illustrating the relationship between girth and yield in Clone B.58

tapping period. In clone B.16 the maximum yield of latex was obtained about the 6th day of tapping.

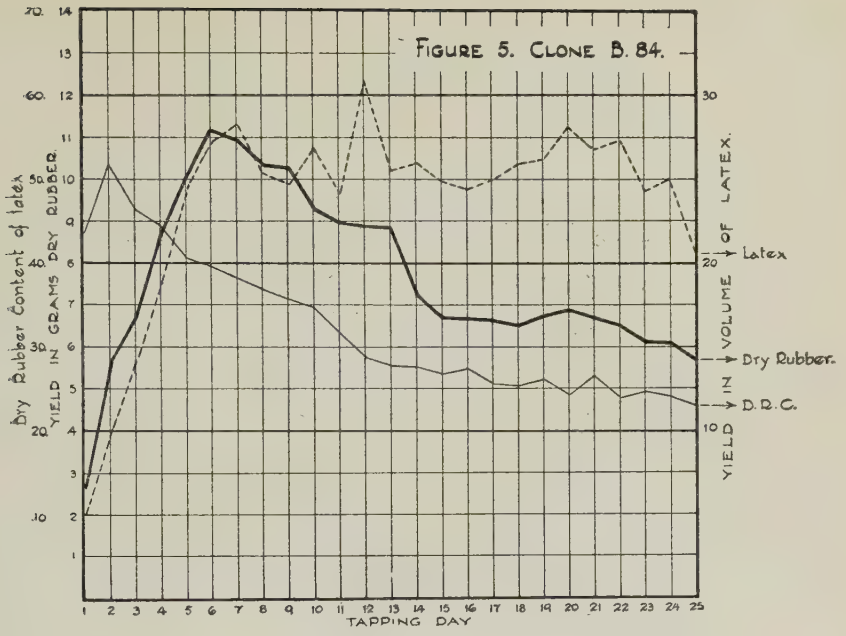
(b) *Yield of dry rubber*

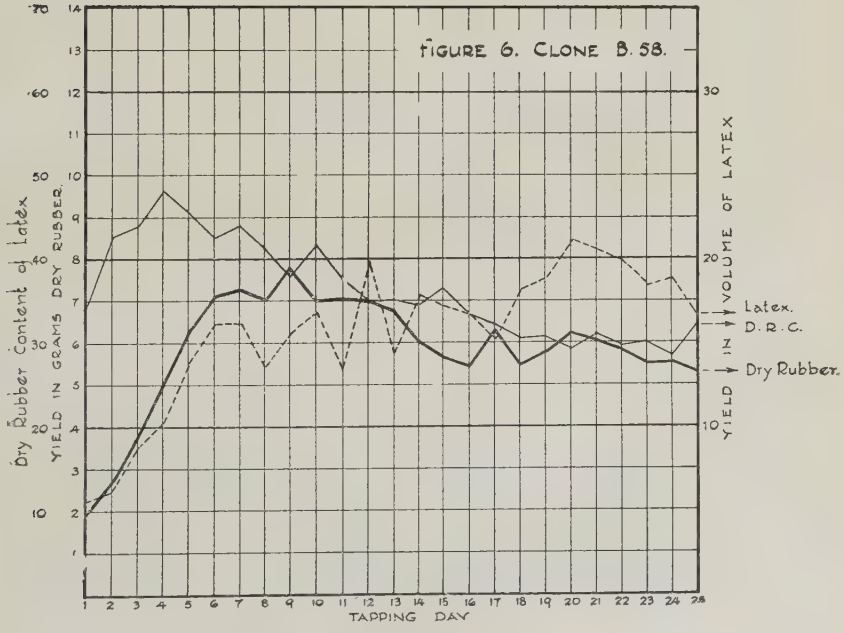
For clones A. 44 and B. 16 the daily yield of dry rubber rises quickly, reaching a maximum on the 6th day, thereafter falling rather abruptly to a level which is considerably below the average for the month. The yield curves for clones B. 84 and D. 61 are of the same general type, but the fall in yield, after the maximum is reached





Figures 3 & 4—Showing the daily changes in total yield of latex, dry rubber and dry rubber content in Clones A.44 and B.16





Figures 5 & 6—Showing the daily changes in total yield of latex, dry rubber and dry rubber content in Clones B.84 & B.58

TABLE IV

Day to day Variation in Mean Yield per Tree (gm. dry rubber exclusive of scrap) in Clone A.44.—40 Trees

Tapping Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Mean
1st Period	**Mean daily yield per tree (gm. dry rubber) on successive days**																									
Yield in gm.	7.7	9.5	9.5	9.6	10.5	9.5	9.5	8.3	7.8	5.3	7.5	7.6	6.9	5.8	5.5	4.9	5.5	5.3	4.8	5.3	4.1	4.5	4.9	4.9	4.7	6.7
Standard Deviation ..	3.25	2.83	3.13	2.64	2.34	2.18	2.30	1.97	1.84	1 39	1.81	1.74	1.72	1.36	1.25	1.19	1.22	1.30	1 00	1.45	0.88	1.14	1.13	1.13	1.11	1.34
Coefficient of Variability ..	42.2	29.8	33.0	27 5	22.3	23.0	24.2	23.8	23.6	26.2	24.1	22.9	24.9	23.5	22.7	24.3	22.2	24.5	20.8	27.4	21.5	25.3	23.1	23.1	23.6	20.0
2nd Period	**Mean daily yield per tree (gm. dry rubber) on successive days**																									
Yield in gm.	2.1	6.0	6.7	9.0	7.9	9.8	7.7	7.6	8.5	7.1	6.7	6.3	6.4	5.3	5.4	4.9	6.0	6.5	4.9	6.3	6.0	7.0	6.1	7.0	4.7	6.5
Standard Deviation	1.12	2.23	1.95	2.69	3.07	3.82	3.48	3.09	2.96	2.47	2.19	1.86	2.58	1.49	1.90	1.45	1.54	1.61	1.25	1.59	1.40	1.14	1.02	1.20	0.95	1.99
Coefficient of Variability	53.4	37.2	29.1	29.9	38.9	39.0	45.2	40.6	34.8	34.8	32.7	29.6	37.2	28.1	35.2	29.6	25.7	24.8	25.5	25.2	23.3	16.3	16.7	17.1	20.2	30.8
3rd Period	**Mean daily yield per tree (gm. dry rubber) on successive days**																									
Yield in gm.	4.3	5.7	9.8	10.9	14.7	14.9	12.6	10.9	10.2	11.7	9.0	10.9	9.5	9.3	6.9	7.4	5.8	7.2	6.8	7.0	7.4	6.7	6.0	5.6	5.9	8 7
Standard Deviation	2.5	2.8	3.5	3.9	4.4	4.4	2.8	2.6	2.2	2.8	2.0	2.8	2.7	2.4	2.1	2.0	1.5	1.9	1.9	1.8	1.8	1.6	1.5	1.4	1.4	2.43
Coefficient of Variability ..	57.1	49.1	35 7	35.8	30.0	29.5	22.2	23.9	21.6	24.0	22.2	25.7	28.4	25.8	30.4	27 0	25.9	26.4	27.9	25.7	24.3	23.9	25.0	25.0	23.7	28.6
Mean of 3 periods	**Mean daily yield per tree (gm. dry rubber) on corresponding days of the three periods**																									
Yield in gm.	4.7	7.5	8.7	9.8	11.0	11.4	10.0	8.9	9.1	8.0	7.7	8.2	7.6	6 8	5.9	5.7	5.8	6.3	5.5	6.2	5.9	6.1	5.7	5.8	5.1	7.3
Standard Deviation	1.72	1.81	2.13	2.55	2.71	2.70	2.25	1.95	2.01	1.85	1.77	1.89	1.87	1.47	1.44	1.30	1.15	1.38	1.09	1.32	1.14	1.03	1.03	1.02	0.87	1.40
Coefficient of Variability ..	36.5	24.1	24.5	26.0	24.6	23.7	22.5	21.9	22.1	23.1	23.0	23.1	24.6	21.6	24.4	22.8	19.8	21.9	19.8	21.3	19.3	16.9	18.1	17.6	17.1	19.08

on the 6th day, is more gradual than in clones A. 44 or B. 16. The fall in yield after the initial maximum is reached is even less pronounced in clone B. 58. In clone B. 65 the yield after the 8th or 9th tapping day is relatively constant.

Using the data for clone A.44, the mean daily yield per tree has been calculated for each tapping period and the standard deviation of each daily mean, together with the value of the coefficient of variability have also been obtained. Similar treatment has been applied to the average daily yield figures for corresponding days of the three periods taken together. The results are summarised in Table IV.

In the final column of Table IV, the average daily yields per tree, for each tapping period and for the three periods together are given together with the values of standard deviation and coefficient of variability.

The value of the coefficient of variability shows within fairly narrow limits a general decrease from the first to the last day of a tapping period. During the first few days when the tapper is finding correct "tapping depth," trees vary in performance with the irregu-

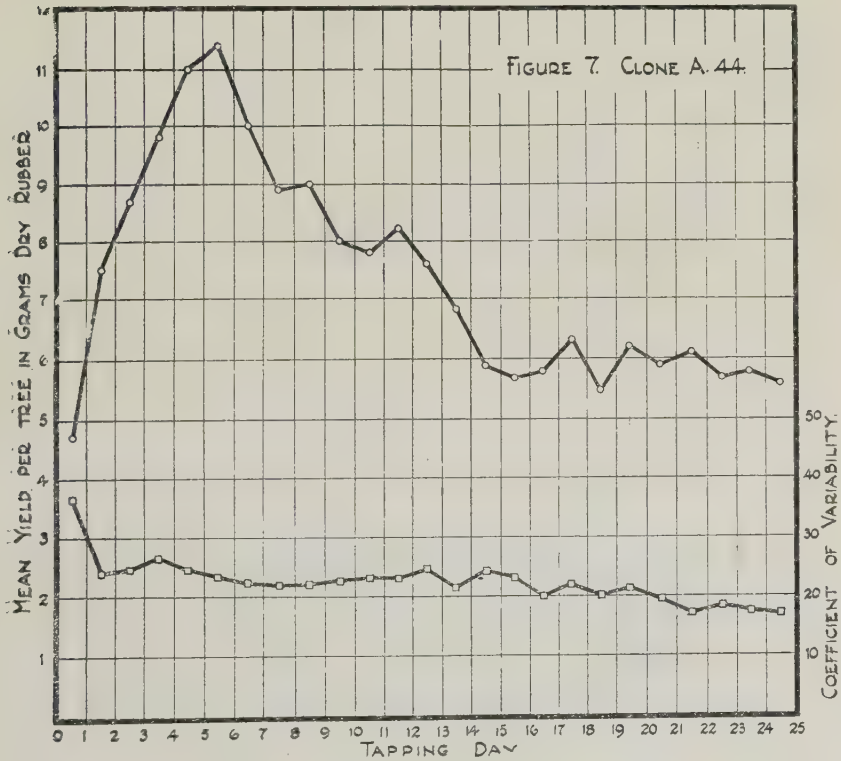


FIGURE 7. CLONE A. 44.
MEAN YIELD PER TREE IN GRAMS DRY RUBBER
COEFFICIENT OF VARIABILITY.
TAPPING DAY
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
1 2 3 4 5 6 7 8 9 10 11
10 20 30 40 50

Figure 7—The variability in daily yield (dry rubber) of 40 trees of Clone A.44 on successive days of a tapping period

TABLE V

Variation in the dry rubber content of the latex from trees of a number of different clones

Clone	No. of Trees	Dry Rubber Content of Latex											
		1st Period June - July			2nd Period Aug. - Sept.			3rd Period Oct. - Nov.			Mean (Whole Period)		
		D.R.C. per cent	Std. Devn.	Coeff. of Variab.	D.R.C. per cent	Std. devn.	Coeff. of Variab.	D.R.C. per cent	Std. Devn.	Coeff. of Variab.	D.R.C. per cent	Std. Devn.	Coeff. of Variab.
B. 84	10	31	± 2.45	7.9	31	± 3.02	9.7	30	± 2.47	8.2	**31**	**± 2.12**	**6.8**
A. 44	40	26	± 2.96	11.4	34	± 3.96	11.6	32	± 2.85	8.9	**30**	**± 2.85**	**9.5**
D. 61	10	35	± 3.51	10.0	41	± 1.79	4.4	36	± 2.92	8.1	**37**	**± 2.00**	**5.4**
B. 16	13	32	± 2.34	7.3	39	± 4.23	10.8	37	± 3.90	10.5	**36**	**± 2.42**	**6.7**
B. 58	30	35	± 2.52	7.2	38	± 3.14	8.3	33	± 2.35	7.1	**35**	**± 2.10**	**6.0**
Seedlings	20	...	...	...	...	...	...	...	...	...	**28**	**± 3.70**	**13.2**

larities which attend this operation. Subsequently, as the tapping becomes more uniform, the value of the variability coefficient for daily yield approaches closely to the average figure for the clone. Figure 7 shows clearly the relationships described above.

(c) *Dry Rubber Content of Latex*

For all clones the dry rubber content of the latex tends to decrease from the beginning to the end of a tapping period. The small irregularities at the beginning of the period are probably due to errors of measurement as the volume of latex on the first two days is generally small and the high dry rubber content makes accurate volume measurements almost impossible.

It is of interest to examine the variation in the quality of the latex from individual trees of the same clone. In order to do this the mean dry rubber content of the latex from each tree has been calculated and the variability in the concentration of the latex has been examined for a number of clones.

The results of this analysis are given in Table V.

For the purpose of comparison the variability of the rubber content of the latex from individual seedling trees has also been examined. The figures are taken from the records made by Sanderson and Sutcliffe (7) on 20 seedlings which were the parents of the budded trees used in the present work.

The results summarised show that the quality of the latex, as indicated by the concentration, is considerably more uniform in budded trees of a clone than in a group of high yielding seedling trees.

The Relation between Yield and the Duration of the Tapping Period

Earlier work on the use of periodic tapping systems with seedlings has shown that, in each tapping period, the yield rises to a maximum after which there is a gradual decline. In periodic tapping the aim should be to obtain the maximum yield consistent with the health of the trees. Increase in brown bast incidence and decrease in dry rubber content of the latex may be taken as indications of overtapping. Work on periodic tapping systems has not been intensive and this is probably accounted for in part by the great variability encountered in an average population of seedling trees. Where a periodic tapping system has been adopted, the choice has generally fallen upon the "alternate monthly" system, i.e. daily tapping for one month followed by one month's rest. In a study of this system, Hoedt (3 & 4) has shown that it may be possible, by shortening the periods of tapping and rest, to obtain an increased yield without impairing the health of the trees. The actual yields for each day of

a tapping period were plotted on a graph. On each day, the average daily yield to date was calculated and the value plotted on the same graph. The curve for actual daily yield reached a maximum after about one week. The curve for mean daily yield was found to rise less rapidly and the maximum value was not reached in Hoedt's experiment until about the fifteenth day.

The curve for the actual daily yield fell more rapidly than the curve for mean daily yield and remained below it for several days towards the end of the tapping period. Hoedt concluded from his results that tapping in the latter part of the month was uneconomic since the actual yield obtained was less than the average yield for the period. It was suggested that the tapping period could be shortened profitably, by cessation of tapping on the fifteenth day, that is, the day when the maximum mean daily yield was obtained. In Hoedt's experiments it appears that the ideal system would be a periodic system of fifteen days tapping, alternating with fifteen days rest. On this basis an increase in yield of 13 per cent. was predicted. It should be stated that the results obtained by Hoedt are not capable of general application. In order to apply this principle, it would be necessary to discover by experiment the actual length of this economic tapping period under different conditions.

The above investigation was carried out on seedling trees among which, trees with widely different yield characteristics must have been represented. The calculated periods will, therefore, be the resultant

TABLE VI

Comparison of the yield responses of different clones

Clone	Day of Maximum Actual Yield	Day of Maximum Mean Daily Yield	No. of days on which actual daily yield is less than mean daily yield	Yield during first 12 days as per cent of total
A. 44	6	7	16	58
B. 16	6	9	16	59
B. 84	6	13	12	55
B. 58	9	14	8	48
B. 65	6	25*	4	47

* The value of mean daily yield appeared to be still increasing even at the 25th day.

of many types for it is possible that, for individual trees, the length of the economic tapping period will show wide variation.

It has already been shown that budded trees of the same clone are relatively more uniform than seedlings in their characters and performance. It has also been demonstrated that the form of the daily yield curves for different clones may show characteristic differences. It is, therefore, of interest to examine these differences in rather more detail on the lines described by Hoedt.

In figures 8 to 12 the values for actual daily yield and mean daily yield to date have been plotted for five different clones. The graphs show the average daily yield per tree on successive days of the three tapping periods (Table I). For all the clones the curve for actual daily yield reaches its maximum before the curve for mean daily yield, but the intervals between the maxima are different for different clones.

It is clear from Figures 8 to 12 and Table VI that clones may show very different responses to the same tapping system. For clones of the A. 44 and B. 16 type, it would appear that the most suitable tapping period is considerably less than twenty five days. For clones of the B. 58, B. 65 type, this period appears to have been suitable. Clone B.84 occupies an intermediate position between such clones as A. 44 and B. 65 in its response to this tapping system. The downward slope of the curve for mean daily yield, after passing its maximum, appears to be a useful index as to whether the tapping system is too severe. It is interesting to note (Figures 3 and 4) that in Clones A. 44 and B. 16 the dry rubber content of the latex reaches a minimum value about the 13th day. In clone B.84 (Figure 5) the corresponding low level is not reached until about the 18th day, whereas in Clone B.65 (Table I) a high dry rubber content is maintained throughout the period. These results support the view that overtapping is reflected in a fall in the dry rubber content of the latex.

In choosing a more suitable tapping system for Clones A.44 and B.16, two courses appear to be open, either to reduce the length of the daily tapping period, or to employ the alternate daily system which has the advantage of giving more rest between tappings.

In the test tapping experiment on other trees of the same clones as those used in the present work and described in the first paper of this series (6), tapping was carried out alternate daily for periods of one month, with monthly rest intervals. It is interesting to note that the yield curves for Clones A. 44 and B. 58 were of essentially the same form as those obtained in the present work. The results of the two investigations are confirmatory in that they show characteristic differences beween clones in their response to tapping.

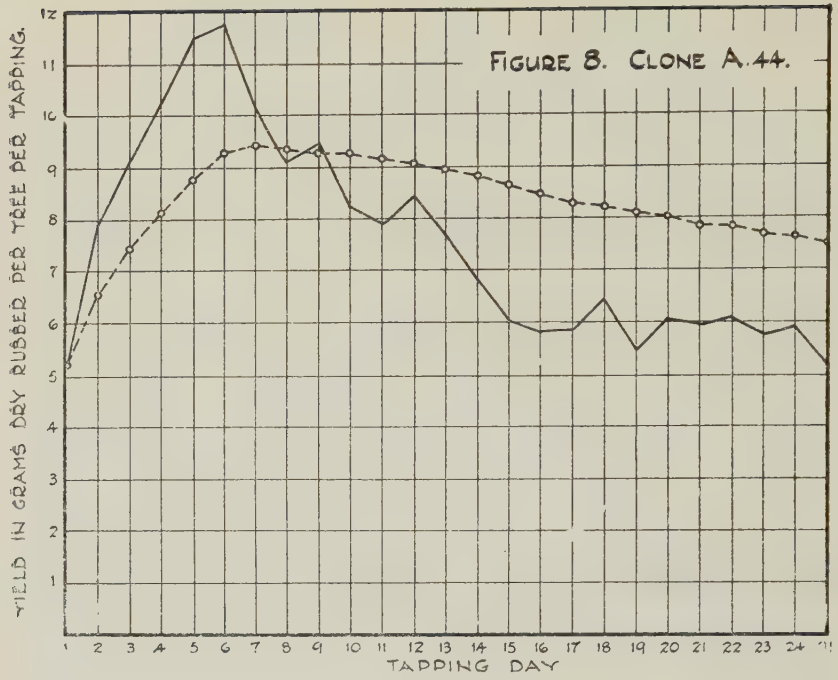


Figure 8—Actual daily yield (solid line) and progressive mean daily yield (dotted line) for Clone A.44

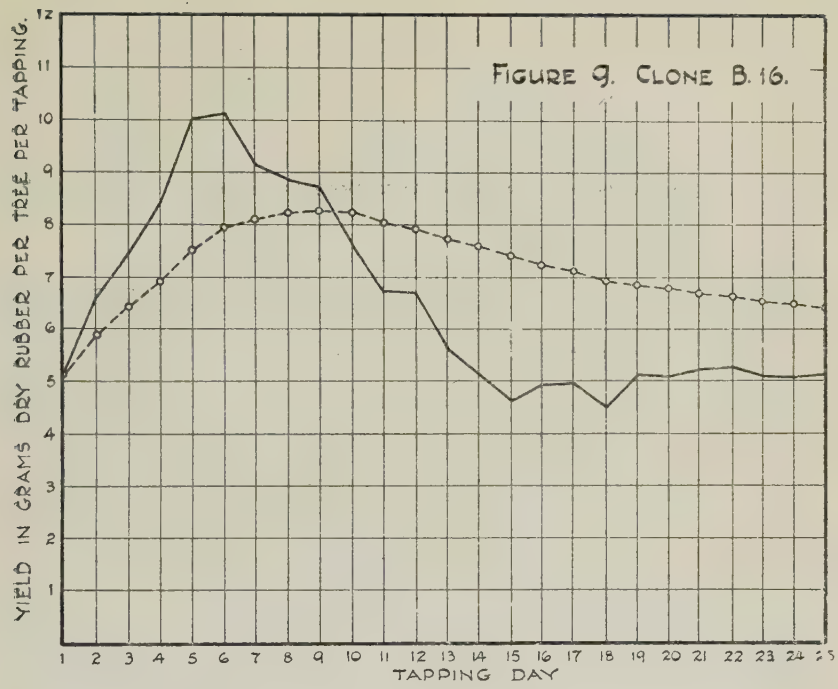
It should be borne in mind, however, that the trees are very young and it remains to be seen whether or not the characteristic differences between clones will be modified with increasing age.

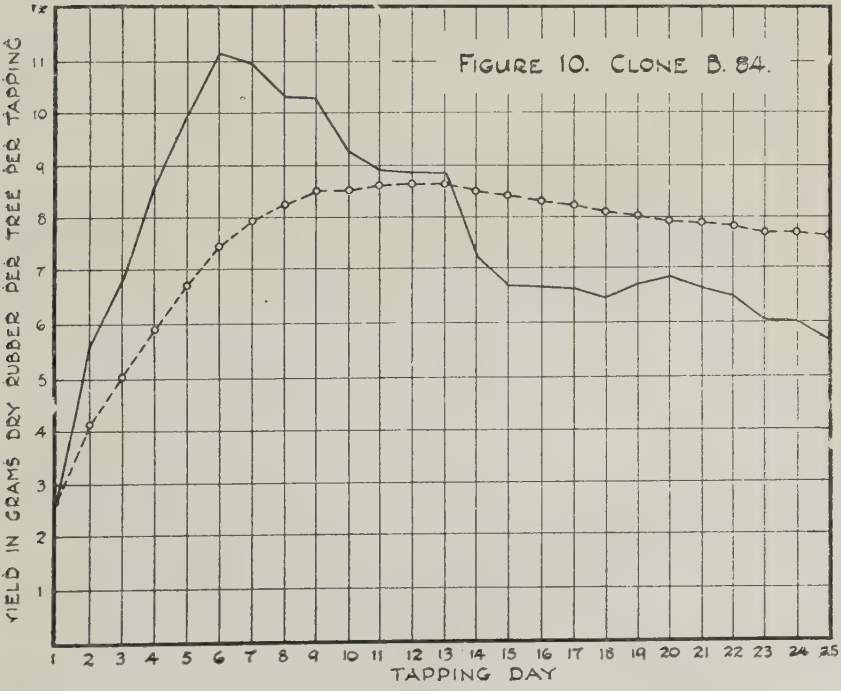
The Influence of Periodic Tapping on Bark Renewal

In May 1929 measurements of bark thickness were made on a number of trees which had been tapped in the foregoing experiment. Measurements of virgin and renewed bark were made together with bark consumption for each of the three tapping periods. The results are summarised in Table VII.

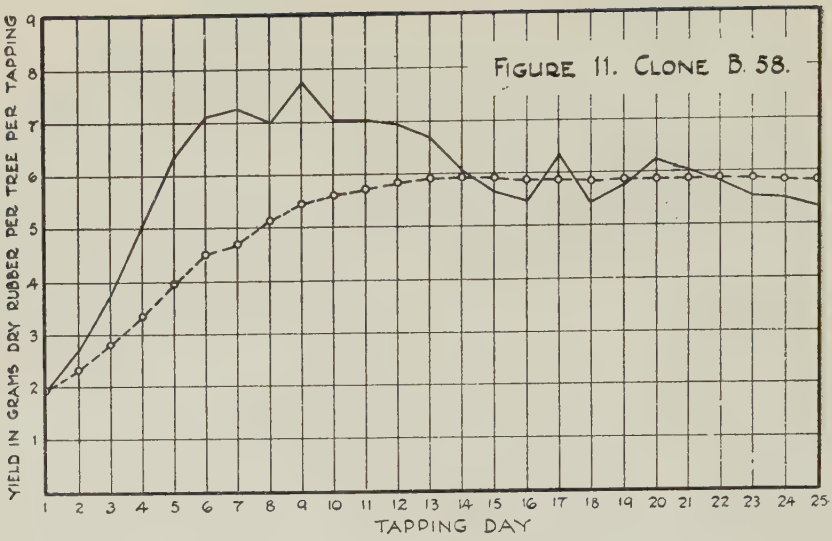
It will be noted that the thickness of the renewed bark was approximately 70 per cent. of that of the virgin bark after a renewal period of eleven months. This rate of recovery may be considered satisfactory. Trees of the same clones employed in the test tapping experiments in which the tapping system was somewhat lighter, showed a more rapid rate of bark renewal. The percentage of renewal after corresponding periods was as follows:—

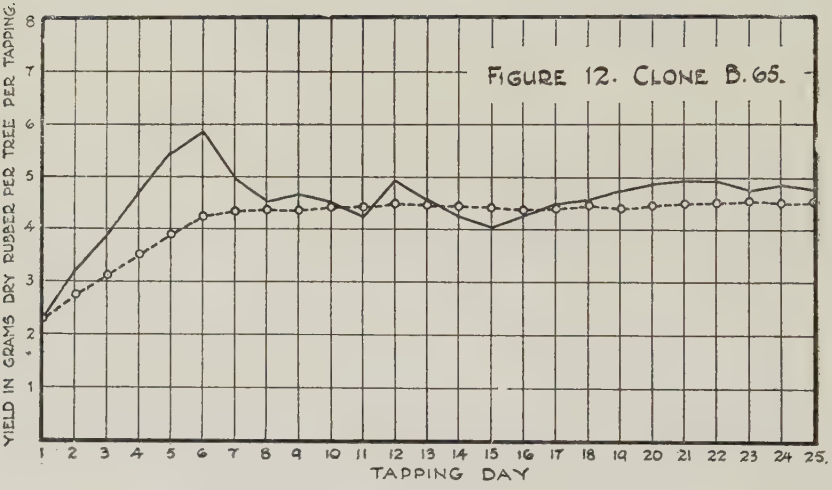
Renewed bark as percentage of virgin bark after:—	*Months.* 7	9	11
Trees tapped daily in alternate months:— ...	60	67	69
Trees tapped alternate daily in alternate months:—	68	75	79





Figures 9 & 10—Actual daily yield (solid line) and progressive mean daily yield (dotted line) for Clones B.16 and B.84





Figures 11 & 12—Actual daily yield (solid line) and progressive mean daily yield (dotted line) for Clones B.58 and B.56

The figures for the alternate daily alternate monthly system are taken from the results published by Billington (1). It appears that the more severe tapping system has a retarding effect on the rate of renewal, but it would be unwise to press the comparison too far, since in the two series of experiments the trees are not strictly comparable.

The figures for bark consumption, given in Table VII, show that the tapping of very young budded trees presents no difficulty.

TABLE VII

Bark thickness, bark renewal and bark consumption in different clones

Clone	Virgin Bark (mm)			Renewed Bark (mm)			Bark Consumption (cm)		
	Above Panel	Below Panel	Mean	7 Months Renewal	9 Months Renewal	11 Months Renewal	1st. Period	2nd. Period	3rd. Period
B 84	6 4	6.6	6.5	4.2	4.7	4.9	4.4	3.8	3.4
			100	*61*	*66*	*71*			
A 44	5.9	5.9	5 9	3.6	3,9	4.2	3.9	3.7	3.4
			100	*65*	*72*	*75*			
D 61	6.2	6.4	6.3	3.6	4.0	4.0	4.3	3.6	3.2
			100	*57*	*63*	*63*			
B 16	6.8	7.2	7.0	4.1	4.5	4 6	4.2	3.3	3.1
			100	*59*	*64*	*66*			
B 58	5.9	6.1	6.0	3.6	4.1	4.3	4.3	3.7	3.3
			100	*60*	*68*	*72*			
Mean	Renewed bark as per cent virgin bark		100	60	67	69			
				Average bark consumption			4.2	3.6	3.3
				Number of cuts per inch			15	18	19

Note:—Percentage figures in italics

Summary

1. An investigation has been made of the response of different clones to tapping under a periodic system.
2. It has been shown that trees of the same clone show a much greater degree of uniformity than an average population of seedling trees. This is evidenced by the high degree of correlation between tree girth and yield and by the comparative uniformity of the dry rubber content of the latex from trees of the same clone.
3. The existence of characteristic differences between clones in their response to a periodic tapping system has been demonstrated.
4. The results suggest that, in order to obtain optimum yield performance, the choice of the tapping system should be determined by the individual characteristics of the clone.

Acknowledgement

The writers wish to acknowledge their indebtedness to the Pilmoor Rubber Company and to the late Manager, Mr. W. H. Bragg, and the staff of Pilmoor Estate for their interest and assistance in the progress of this work.

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Appendix

Detailed Daily Records of the best Clones

TABLE I

Average daily record of yield of latex, dry rubber (including scrap) and dry rubber content of the latex in Clone B. 84. 10 Trees

1st. Period				2nd. Period				3rd. Period				Mean of 3 periods		
Date 1928 June July	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Date 1928 Aug. Sept.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Date 1928 Oct. Nov.	Dry Rubber gm.	Vol. Latex. c.c.	Dry Rubber Content per cent	Dry Rubber gm.	Vol. Latex. c.c.	Dry Rubber Content per cent
14/6	2.87	6.2	42.4	14/8	2.18	3.4	51.5	14/10	2.97	5.4	36.1	2.67	5.0	43.3
15/6	3.11	6.3	46.4	15/8	4.96	8.1	55.9	15/10	8.75	15.4	53.4	5.61	10.0	51.9
16/6	3.64	8.3	42.9	16/8	5.97	10.5	52.8	16/10	11.04	24.4	43.2	6.88	14.4	46.3
17/6	5.49	12.1	44.9	17/8	8.52	19.2	42.9	17/10	11.88	25.1	45.6	8.63	18.8	44.5
18/6	6.59	16.6	39.4	*R18/8	9.20	19.8	44.4	18/10	14.20	37.3	36.9	10.00	24.6	40.2
19/6	6.44	17.1	37.3	19/8	11.53	27.7	40.7	19/10	15.56	36.4	41.5	11.18	27.1	39.8
20/6	6.91	17.9	37.7	20/8	12.94	31.3	38.0	20/10	14.00	35.6	38.6	10.98	28.3	38.1
21/6	6.63	17.8	36.2	21/8	11.83	32.8	35.6	21/10	12.49	Rain	...	10.32	25.3	36.9
22/6	6.45	18.3	34.3	22/8	11.71	31.0	37.2	22/10	12.60	Rain	...	10.29	24.7	35.8
23/6	5.07	12.8	38.3	23/8	9.29	26.8	34.0	23/10	13.32	40.7	32.1	9.23	26.8	34.8
24/6	6.21	19.0	31.8	24/8	9.15	28.9	31.1	24/10	11.47	Rain	...	8.94	24.0	31.5
25/6	6.03	21.6	29.8	25/8	7.39	24.6	29.3	25/10	12.58	46.0	20.8	8.87	30.7	28.6
26/6	6.78	23.2	28.8	26/8	7.54	27.8	26.8	26/10	12.29	Rain	...	8.87	25.5	27.8
27/6	5.72	20.2	27.9	R27/8	6.32	21.2	29.3	27/10	9.60	36.0	26.3	7.21	25.8	27.8
28/6	5.65	20.2	27.6	28/8	5.85	22.3	25.8	28/10	8.70	31.8	26.9	6.74	24.8	26.8
29/6	5.31	18.8	27.7	R29/8	5.90	21.1	27.5	29/10	8.86	33.2	26.3	6.69	24.4	27.2
30/6	5.56	21.6	25.3	30/8	6.26	24.1	25.6	30/10	8.02	Rain	...	6.61	24.9	25.5
1/7	5.31	18.4	28.4	31/8	6.35	25.7	24.4	31/10	7.84	33.0	22.9	6.50	25.9	25.2
2/7	5.00	19.9	24.7	R 1/9	6.23	20.3	30.0	1/11	9.11	38.3	23.5	6.78	26.2	26.1
3/7	5.91	23.6	24.7	2/9	6.66	26.0	25.1	2/11	8.03	34.8	22.7	6.87	28.1	24.2
4/7	4.60	14.0	32.3	3/9	5.92	22.4	25.8	3/11	9.54	43.9	21.5	6.69	26.8	26.5
5/7	4.64	17.8	25.6	4/9	6.08	26.6	24.6	4/11	8.17	37.3	21.6	6.50	27.2	23.9
6/7	5.51	21.9	24.8	5/9	5.65	21.1	26.1	5/11	7.06	29.7	23.3	6.09	24.2	24.7
7/7	4.75	18.8	24.8	6/9	7.15	29.5	23.8	6/11	6.35	26.7	23.3	6.08	25.0	24.0
8/7	5.05	19.4	25.6	7/9	5.49	17.4	30.7	7/11	6.34	25.1	27.5	5.63	20.6	27.9
Average	**5.43**	**17.3**	**30.8**	Average	**7.43**	**22.8**	**31.8**	Average	**10.03**	**31.7**	**29.7**	**7.63**	**23.4**	**30.7**

* R = Early morning rain—Late tapping.

TABLE I— *(Continued)*

Average daily record of yield of latex, dry rubber (including scrap) and dry rubber content of the latex in Clone A. 44. 40 Trees

1st. Period				2nd. Period				3rd. Period				Mean of 3 periods		
Date 1928 June July	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Date 1928 Aug. Sept.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Date 1928 Oct. Nov.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.
14/6	7.87	15.7	48.9	14/8	2.43	3.7	57.8	14/10	5.32	10.2	41.9	5.21	9.9	49.5
15/6	9.65	22.3	42.5	15/8	6.32	10.9	53.6	15/10	7.82	12.1	57.3	7.93	15.1	51.1
16/6	9.71	24.4	39.1	16/8	7.03	13.7	49.0	16/10	10.66	16.9	58.1	9.13	18.3	48.7
17/6	9.79	24.6	39.0	17/8	9.21	20.5	43.6	17/10	11.67	21.6	50.4	10.22	22.2	44.3
18/6	10.70	31.7	33.2	*R18/8	8.36	15.4	51.0	18/10	15.42	35.1	41.7	11.49	27.4	42.0
19/6	9.69	31.0	30.7	19/8	10.01	24.6	39.7	19/10	15.66	32.2	46.2	11.79	29.3	38.9
20/6	9.53	32.6	29.3	20/8	7.86	18.6	41.4	20/10	12.94	30.5	41.3	10.14	27.2	37.3
21/6	8.37	30.1	27.5	21/8	7.73	19.7	38.4	21/10	11.14	27.9	38.9	9.08	25.9	34.9
22/6	7.92	32.9	23.8	22/8	8.70	24.7	34.5	22/10	11.70	Rain	...	9.44	28.8	29.2
23/6	5.42	18.9	28.2	23/8	7.27	21.1	33.6	23/10	12.00	35.6	32.8	8.23	25.2	31.5
24/6	7.63	33.3	22.6	24/8	6.87	20.3	33.1	24/10	9.25	Rain	...	7.92	26.8	27.9
25/6	7.66	36.2	29.9	25/8	6.43	20.4	30.7	25/10	11.22	42.0	26.0	8.44	32.9	25.9
26/6	6.96	35.0	19.8	26/8	6.54	23.3	27.5	26/10	9.57	Rain	...	7.69	29.2	23.7
27/6	5.81	30.1	16.2	R27/8	5.48	16.0	33.4	27/10	9.38	38.9	23.8	6.89	28.3	25.5
28/6	5.52	30.5	18.0	28/8	5.57	19.5	27.9	28/10	6.99	26.1	26.3	6.03	25.4	24.1
29/6	4.95	26.3	18.7	R29/8	5.02	15.1	32.3	29/10	7.53	30.0	24.7	5.83	23.8	25.3
30/6	5.49	29.7	18.4	30/8	6.12	20.7	28.9	30/10	5.93	23.9	24.3	5.85	24.8	23.9
1/7	5.36	26.7	10.9	31/8	6.62	23.7	27.4	31/10	7.31	33.3	21.6	6.43	27.9	23.0
2/7	4.80	25.8	18.5	R 1/9	4.88	14.4	33.0	1/11	6.97	29.0	23.5	5.55	23.1	25.0
3/7	5.30	27.3	19.3	2/9	6.45	22.5	28.1	2/11	7.16	31.5	22.2	6.30	27.1	23.2
4/7	4.17	16.9	24.5	3/9	6.10	22.8	26.2	3/11	7.59	33.1	22.4	5.95	24.3	24.4
5/7	4.50	22.4	19.9	4/9	7.11	27.9	25.1	4/11	6.89	29.2	23.1	6.17	26.5	22.7
6/7	4.94	23.5	20.9	5/9	6.20	22.6	26.9	5/11	6.14	23.1	25.9	5.76	23.1	24.2
7/7	4.89	24.4	19.9	6/9	7.14	29.2	24.0	6/11	5.74	20.1	27.7	5.92	24.6	23.9
8/7	4.09	21.0	22.2	7/9	4.77	14.5	32.2	7/11	6.00	21.1	27.7	5.15	18.9	27.4
Average	**6.87**	**26.92**	**25.2**	Average	**6.65**	**19.44**	**33.3**	Average	**9.07**	**27.4**	**31.4**	**7.53**	**24.5**	**29.5**

* R=Early morning rain—Late tapping.

TABLE I—*(Continued)*

Average daily records of yield of latex, dry rubber (including scrap) and dry rubber content of the latex in Clone D 61. 10 Trees

1st. Period				2nd. Period				3rd. Period				Mean of 3 periods		
Date 1928 June July	Dry Rubber gm.	Vol. Latex c. c.	Dry Rubber Content per cent.	Date 1928 August Sept.	Dry Rubber gm.	Vol. Latex c. c.	Dry Rubber Content per cent.	Date 1928 Oct. Nov.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent
14/6	4.65	8.20	49.8	14/8	2.32	2.0	*C	14/10	3.64	5.1	47.9	3.54	5.1	48.9
15/6	3.97	7.3	50.0	15/8	4.05	5.7	C	15/10	7.29	7.6	C	5.10	6.9	50.0
16/6	5.89	12.7	44.1	16/8	5.40	7.6	C	16/10	9.30	15.2	56.4	6.83	11.8	50.3
17/6	7.29	16.3	43.5	17/8	6.91	12.7	52.2	17/10	9.21	14.8	58.4	7.8	14.6	51.4
18/6	7.78	18.9	40.1	*R18/8	7.45	12.5	56.7	18/10	12.19	25.5	45.6	9.14	19.0	47.5
19/6	8.21	20.8	38.4	19/8	10.14	20.0	48.9	19/10	11.64	21.3	52.0	10.0	20.7	46.4
20/6	8.57	21.9	38.2	20/8	9.06	18.3	48.2	20/10	10.35	21.5	46.7	9.32	20.6	44.4
21/6	7.76	19.9	38.0	21/8	8.45	17.2	47.7	21/10	10.50	Rain	...	8.90	18.6	42.9
22/6	7.40	21.3	33.7	22/8	9.56	20.1	46.3	22/10	11.90	Rain	...	9.62	20.7	40.0
23/6	4.81	12.6	36.4	23/8	8.27	17.3	46.4	23/10	12.15	29.8	39.7	8.41	19.9	40.8
24/6	6.59	19.0	33.5	24/8	8.49	19.6	42.0	24/10	12.12	Rain	...	9.07	19.3	37.8
25/6	6.75	21.2	30.8	25/8	8.31	21.3	37.9	25/10	12.33	33.3	36.1	9.13	25.3	34.9
26/6	6.37	19.5	31.8	26/8	7.46	19.0	38.4	26/10	11.68	Rain	...	8.50	19.2	35.1
27/6	5.06	15.7	31.2	R27/8	6.30	15.1	40.6	27/10	10.62	32.0	32.4	7.33	20.9	34.7
28/6	5.38	17.0	30.7	28/8	6.93	19.4	34.9	28/10	8.76	26.1	32.6	7.02	20.8	32.7
29/6	4.86	15.8	29.7	R29/8	6.54	17.6	36.2	29/10	9.83	31.2	30.7	7.08	21.5	32.2
30/6	5.73	19.7	28.2	30/8	7.44	20.2	36.0	30/10	7.86	Rain	...	7.01	19.9	32.1
1/7	4.32	13.5	30.7	31/8	7.18	21.0	33.4	31/10	8.09	28.0	28.0	6.53	20.8	30.7
2/7	5.13	18.4	27.9	R 1/9	6.54	17.9	35.5	1/11	9.26	31.6	28.8	6.98	22.6	30.7
3/7	5.10	17.0	30.0	2/9	7.24	20.8	33.9	2/11	8.63	31.2	27.1	6.99	23.0	30.3
4/7	4.06	12.4	32.8	3/9	6.61	18.7	34.4	3/11	9.12	34.4	26.1	6.60	21.8	31.1
5/7	4.65	14.9	31.2	4/9	6.43	18.3	34.2	4/11	8.32	29.1	28.0	6.46	20.8	31.1
6/7	5.14	16.0	32.1	5/9	6.13	17.6	33.8	5/11	7.57	25.6	28.9	6.28	19.7	31.6
7/7	4.84	16.3	29.7	6/9	6.97	22.3	30.4	6/11	6.59	22.7	28.3	6.13	20.4	29.5
8/7	4.95	15.6	31.7	7/9	5.67	15.1	36.4	7/11	7.43	24.2	30.1	6.02	18.3	32.7
Average	**5.85**	**16.5**	**34.3**	Average	**7.04**	**16.7**	**40.7**	Average	**9.41**	**24.5**	**35.6**	**7.43**	**18.8**	**36.8**

* R=Early morning rain—Late tapping.

* C=Latex coagulated in cup.

TABLE I—*(Continued)*

Average daily record of yield of latex, dry rubber (including scrap) and dry rubber content of the latex in Clone B. 16. 13 Trees

1st. Period				2nd. Period				3rd. Period				Mean of 3 periods		
Date 1928 June July	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Date 1928 Aug. Sept.	Dry Rubber gm.	Vol. Latex. c.c.	Dry Rubber Content per cent.	Date 1928 Oct. Nov.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.
14/6	5.32	8.8	52.8	14/8	4.49	*C	...	14/10	5.68	8.0	62.7	5.10	8.4	57.8
15/6	6.00	12.3	46.7	15/8	5.68	C	...	15/10	8.24	12.2	62.9	6.64	12.3	54.8
16/6	6.82	15.5	43.1	16/8	6.45	10.3	55.7	16/10	9.15	16.5	52.6	7.47	14.1	50.5
17/6	7.40	19.6	36.9	17/8	8.31	17.8	43.2	17/10	10.51	20.3	49.5	8.41	19.2	43.2
18/6	7.84	21.0	36.5	*R 18/8	8.93	17.5	48.2	18/10	13.33	32.5	39.5	10.03	23.7	44.7
19/6	7.04	20.5	33.6	19/8	9.00	19.1	46.8	19/10	13.71	31.2	42.4	10.12	23.6	40.9
20/6	7.53	22.4	32.8	20/8	9.04	22.5	39.3	20/10	10.89	24.3	43.8	9.15	23.1	38.6
21/6	6.93	19.8	34.0	21/8	9.04	24.6	35.9	21/10	10.57	Rain	...	8.85	22.2	35.0
22/6	5.97	20.0	28.9	22/8	9.68	27.2	34.8	22/10	10.69	Rain	..	8.78	23.6	31.9
23/6	4.40	11.8	35.5	23/8	8.10	23.4	33.8	23/10	10.32	26.7	37.8	7.61	20.6	35.7
24/6	4.94	15.8	30.0	24/8	6.95	19.9	33.8	24/10	8.24	Rain	...	6.71	17.9	31.9
25/6	4.83	16.3	28.5	25/8	6.84	21.5	30.8	25/10	8.49	25.4	32.5	6.72	21.1	30.0
26/6	4.45	15.4	27.9	26/8	4.80	15.6	29.8	26/10	7.63	Rain	...	5.63	15.5	28.9
27/6	4.01	12.7	30.3	R 27/8	4.30	11.3	36.7	27/10	7.16	20.6	33.7	5.16	14.9	33.6
28/6	4.17	14.9	27.1	28/8	3.85	11.8	31.5	28/10	5.96	18.1	31.6	4.66	14.9	30.1
29/6	4.09	14.8	26.6	R 29/8	4.43	12.5	34.4	29/10	6.38	20.8	29.7	4.97	16.0	30.2
30/6	4.37	16.1	26.2	30/8	4.42	13.5	31.5	30/10	6.17	Rain	...	4.99	14.8	28.9
1/7	3.75	12.1	29.8	31/8	4.75	13.9	33.1	31/10	5.12	15.2	32.3	4.54	13.7	31.7
2/7	4.07	14.6	27.0	R 1/9	5.08	13.5	35.8	1/11	6.33	19.6	31.1	5.16	15.9	31.3
3/7	4.15	14.1	28.5	2/9	5.06	13.6	35.4	2/11	6.11	19.1	30.8	5.14	15.6	31.6
4/7	3.46	10.3	32.3	3/9	4.85	12.8	30.0	3/11	7.45	24.0	30.1	5.26	15.7	32.8
5/7	3.86	12.0	31.1	4/9	5.26	14.2	35.2	4/11	6.71	19.0	34.1	5.28	15.1	33.5
6/7	4.08	14.0	28.3	5/9	5.14	13.8	35.5	5/11	6.15	18.2	32.6	5.12	15.3	32.1
7/7	4.13	14.5	27.5	6/9	5.46	15.9	32.9	6/11	5.09	17.0	32.1	5.00	15.8	30.8
8/7	4.15	12.9	31.1	7/9	5.65	11.8	37.2	7/11	6.65	19.2	33.4	5.15	14.6	33.9
Average	**5.11**	**15.3**	**32.2**	Average	**6.20**	**15.6**	**37.7**	Average	**8.09**	**20.4**	**37.7**	**6.43**	**16.9**	**35.9**

* R=Early morning rain—Late tapping.

* C=Latex coagulated in cup.

TABLE I—*(Continued)*

Average daily record of yield of latex, dry rubber (including scrap) and dry rubber content of the latex in Clone B. 58. 30 Trees

1st. Period				2nd. Period				3rd. Period				Mean of 3 periods		
Date 1928 June July	Dry Rubber gm.	Vol. Latex cc.	Dry Rubber Content per cent.	Date 1928 Aug. Sept.	Dry Rubber gm.	Vol. Latex cc.	Dry Rubber Content per cent.	Date 1928 Oct. Nov.	Dry Rubber gm.	Vol. Latex cc.	Dry Rubber Content per cent.	Dry Rubber gm.	Vol. Latex. c.c.	Dry Rubber Content percent.
14/6	2.92	6.9	39.8	14/8	1.43	*C	...	14/10	1.55	4.0	28.8	1.97	5.5	34.3
15/6	2.91	6.1	46.3	15/8	2.42	C	...	15/10	2.77	6.2	39.5	2.70	6.2	42.9
16/6	3.62	8.0	44.3	16/8	3.03	4.6	...	16/10	4.71	9.8	43.7	3.79	7.5	44.0
17/6	4.78	10.6	44.4	17/8	4.33	8.2	51.1	17/10	6.20	11.8	49.3	5.10	10.2	48.3
18/6	5.59	13.9	39.9	*R18/8	5.00	8.8	53.6	18/10	8.33	18.7	42.5	6.31	13.8	45.3
19/6	5.16	13.4	37.9	19/8	6.33	15.2	41.0	19/10	9.91	19.6	48.7	7.13	16.1	42.5
20/6	5.70	14.2	39.6	20/8	6.41	13.7	46.0	20/10	9.60	20.6	45.5	7.24	16.2	43.7
21/6	5.23	14.1	36.5	21/8	5.95	12.9	45.4	21/10	9.82	Rain	...	7.00	13.5	41.0
22/6	5.10	13.4	37.4	22/8	6.90	17.7	38.3	22/10	11.38	Rain	...	7.79	15.6	37.9
23/6	3.97	9.7	40.0	23/8	5.20	11.2	45.3	23/10	11.82	29.7	39.0	7.00	16.9	41.4
24/6	5.03	14.3	34.5	24/8	5.18	12.5	40.5	24/10	10.81	Rain	...	7.01	13.4	37.5
25/6	5.06	14.6	34.0	25/8	4.67	12.1	37.6	25/10	11.15	33.0	33.0	6.96	19.9	34.9
26/6	5.18	15.1	33.9	26/8	4.92	13.4	36.1	26/10	10.04	Rain	...	6.71	14.3	35.0
27/6	4.29	13.2	32.1	R27/8	4.59	11.3	40.0	27/10	9.14	28.9	31.1	6.01	17.8	34.4
28/6	4.36	13.7	31.6	28/8	4.48	12.4	35.6	28/10	8.10	25.1	31.7	5.65	17.1	36.3
29/6	4.08	12.5	32.2	R29/8	4.56	12.0	37.3	29/10	7.78	25.4	30.1	5.47	16.6	33.2
30/6	4.50	14.8	30.1	30/8	5.35	15.5	34.1	30/10	7.22	Rain	...	6.36	15.2	32.1
1/7	4.08	11.9	33.9	31/8	5.22	16.3	31.5	31/10	7.02	26.3	26.1	5.44	18.2	30.5
2/7	3.86	13.8	27.7	R 1/9	5.66	15.4	36.0	1/11	7.80	27.3	28.2	5.77	18.8	30.6
3/7	4.38	15.0	28.9	2/9	7.23	22.4	31.8	2/11	7.03	25.9	26.7	6.21	21.1	29.1
4/7	3.97	11.2	35.2	3/9	5.48	16.8	32.1	3/11	8.61	33.5	25.4	6.02	20.5	30.9
5/7	3.80	12.0	31.4	4/9	6.07	19.4	30.7	4/11	7.53	28.3	26.3	5.80	19.9	29.5
6/7	4.25	13.6	30.9	5/9	5.17	16.9	31.7	5/11	7.13	25.5	27.5	5.52	18.4	30.0
7/7	3.86	13.0	29.3	6/9	6.30	21.9	28.3	6/11	6.25	21.8	28.3	5.48	18.9	28.6
8/7	4.03	12.5	31.9	7/9	4.81	13.0	36.3	7/11	7.13	24.4	28.8	5.32	16.6	32.3
Average	**4.39**	**12.5**	**34.7**	Average	**5.07**	**13.1**	**37.8**	Average	**7.95**	**22.3**	**32.6**	**5.81**	**15.5**	**34.8**

* R=Early morning rain—Late tapping.

* C=Latex coagulated in cup.

TABLE I—*(Concluded)*

Average daily record of yield of latex, dry rubber (including scrap) and dry rubber content of the latex in Clone B. 65. 8 Trees

1st. Period				2nd. Period				3rd. Period				Mean of 3 periods		
Date 1928 June July	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent	Date 1928 Aug. Sept.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Date 1928 Oct. Nov.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.	Dry Rubber gm.	Vol. Latex c.c.	Dry Rubber Content per cent.
14/6	2.54	4.38	52.0	14/8	1.48	*C	..	14/10	2.89	4.4	47.2	2.30	3.19	49.6
15/6	1.71	2.97	48.7	15/8	2.65	C	...	15/10	5.33	7.5	63.2	3.23	4.52	55.95
16/6	2.46	3.81	57.6	16/8	3.64	C	...	16/10	5.60	10.0	51.2	3.90	6.24	54.4
17/6	3.45	5.94	53.6	17/8	4.94	8.5	52.4	17/10	5.68	10.5	49.7	4.69	8.31	51.9
18/6	3.73	7.00	49.5	*R18/8	4.73	7.7	57.2	18/10	7.76	18.0	40.5	5.41	10.90	49.06
19/6	4.00	8.88	42.1	19/8	6.50	13.4	46.5	19/19	7.04	13.5	48.7	5.85	11.93	45.76
20/6	3.53	8.38	42.2	20/8	5.09	10.5	46.1	20/10	6.29	14.4	42.0	4.97	11.03	43.43
21/6	3.24	7.19	45.1	21/8	4.70	7.8	57.5	21/10	5.69	Rain	...	4.54	7.49	51.3
22/6	3.56	8.69	41.0	22/8	4.63	9.8	44.9	22/10	5.79	Rain	...	4.65	9.24	42.95
23/6	2.35	4.44	52.9	23/8	4.87	10.0	46.2	23/10	6.48	16.4	38.1	4.37	10.28	45.73
24/6	3.57	9.00	39.7	24/8	4.02	7.4	51.2	24/10	5 22	Rain	...	4.27	8.2	45.45
25/6	3.66	9.38	39.0	25/8	4.60	10.5	41.4	25/10	6.31	17.3	35.1	4.86	12.39	38.5
26/6	3.29	8.38	39.3	26/8	4.03	9.5	40.1	26/10	6.25	Rain	...	4.52	8.94	39.7
27/6	2.99	7.63	39.3	R27/8	3.81	7.9	45.6	27/10	6.05	18 8	31.0	4.28	11.44	38.63
28/6	3.57	9.06	39.4	28/8	3.71	9.1	38.3	28/10	4.79	13.9	32.8	4.02	10.69	36.83
29/6	3.23	8.69	37.2	R29/8	4.06	9.3	41.5	29/10	5.45	15.8	33.1	4.25	11.26	37.26
30/6	4.17	11.38	36.6	30/8	4.23	9.5	42.2	30/10	4.84	Rain	...	4.41	10.44	39.4
1/7	3.26	7.50	43.5	31/8	4.43	11.0	38.3	31/10	4.72	13.5	33.2	4.14	10.66	38.3
2/7	4.08	11.1	34.6	R 1/9	4.54	10.1	42.1	1/11	5.63	15.1	35.9	4.75	12.1	37.53
3/7	4.41	11.4	36.8	2/9	4.89	11.8	39.3	2 11	5.34	15.5	33.1	4.88	12.9	36.4
4 7	3.23	7.4	40.7	3/9	4 73	10.8	41.4	3 11	6.86	22.3	29.9	4.94	13.5	37.3
5 7	3.93	10.0	37.1	4 9	4.90	11.9	39.7	4 11	5.91	18.1	31.5	4.91	13.33	36.1
6 7	4.33	11.1	36.8	5/9	4.58	10.8	40.0	5 11	5.38	15.6	33.1	4.76	12.5	36.63
7 7	4.13	12.0	32.5	6/9	5.36	14.9	34.2	6 11	4.93	13.1	36.0	4.81	13.33	34.23
8 7	4.47	11.8	35.9	7 9	4.08	9.4	40.6	7 11	5.73	16.1	34.3	4.76	12.43	36.93
Average	**3.61**	**8.3**	**40.3**	Average	**4.37**	**9.2**	**44.4**	Average	**5.62**	**14.5**	**37.2**	**4.53**	**10.40**	**40.4**

* R=Early morning rain—Late tapping.

* C=Latex coagulated in cup.

NOTES ON THE YIELD PERFORMANCE OF BUDDED TREES OF PROVED CLONES IN COMMERCIAL PRACTICE

It is a fact that much of our evidence concerning the value of buddings of proved clones is based on the results of careful tapping and recording of individual yields of small numbers of trees. At the same time it must be emphasised that the character of uniformity within a single clone is of outstanding importance. Having once demonstrated that the high yielding property is possessed by every member of a very small group of trees derived by vegetative means from a single individual or mother tree then it is certain that this desirable property will be exhibited by all trees propagated from the same source. From the enquiries we have received and from conversations with estate managers in the course of advisory work the writer is convinced that this fundamental principle of vegetative propagation is not fully appreciated. As a result quite untenable arguments are still advanced against the principle and practice of budding in the commercial cultivation of Hevea.

There is no doubt that confusion has been created in many minds by the elimination of certain clones from the list of those recommended for planting. Although the reasons for rejecting clones, previously recommended for use, have always been clearly stated this has apparently failed to prevent the formation of quite erroneous impressions. It appears to have been assumed that a clone removed from the recommended list must have failed entirely in its capacity to give high yields. In no instance has this been true; rejection has always been decided upon after continued study of both the yield performance and the secondary characters such as susceptibility to disease, resistance to mechanical damage, character of bark renewal and the like. Though the high yielding properties may be satisfactorily maintained the development of a secondary defect with increase in age of the buddings may justify the rejection of certain clones in favour of others which do not exhibit such undesirable secondary characters.

It should be apparent that the older budded areas in which certain clones were used which have now been rejected will not necessarily prove unprofitable. In the early years at all events, their production will be in accordance with the early records of the first vegetative generation of the clones used. The defects, which we now

know will become apparent with advancing age, can to a large extent be met by careful special treatment.

In view of the large number of enquiries we have received regarding the yields obtainable from commercial plantings of buddings of proved clones the following notes have been prepared.

The information presented is not exhaustive since the object of these notes is to present clear examples, taken from reliable sources, in order to indicate the level of yield performance that may be reasonably expected from the modern budded plantation.

During the past year many estates in Malaya have carried out preliminary tapping tests on buddings of the older proved clones. The results have been very satisfactory; the yields obtained have agreed very closely with those recorded for the buddings of the first vegetative generation of the various clones. At the same time, these records of early tapping tests are of very little value in forming an estimate of the actual yield performance of the various clones under a recognised system of commercial tapping and it is for this reason that detailed reference is not made to the results in these notes. It is sufficient to state that, in no case reported to us, has the performance of a proved clone of undoubted authenticity fallen below expectations in the preliminary tapping tests. In Malaya the performance of several of the older proved clones, particularly the AVROS clones, has exceeded expectations in these preliminary tests. (See Table I).

TABLE I

(i) *Comparative yields of buddings, of certain AVROS clones, and seedlings.*

Yield per acre in pounds

Year	Age	Seedlings	Clone 71	Clone 80	Clone 152	Clone 163
1927	4½ yrs.	134	360	330	450	310
1928	5½ ,,	319	763	532	825	728
1929	6½ ,,	508	1126	779	1200	777
1930	7½ ,,	682	1327	1005	1494	1289

In the first 2 years of tapping, 1927-28, groups of 200 trees, i.e., two plots of approximately 1 acre each, were recorded for each clone and for the seedlings. It was found that there was such close agreement between the yields of duplicated plots that after 1928 only one plot of each clone was recorded in detail, both seedling plots were recorded as before.

Trees were tapped on ½ circumference daily in alternate months for the first year. Subsequently tapping has been on 1/3rd circumference daily in alternate months.

The estate on which this work was carried out was certainly above average as regards soil fertility and general upkeep. At the same time the figures are of considerable value since they show the relative performance of buddings of good proved clones and the best selected seedlings available at the time of planting. The general level of yield of buddings of good clones is so very much higher than that of seedlings that attention has been mainly centred on comparison between clones. There are no detailed figures, so far as we are aware, showing the comparison between seedlings, and buddings of such clones as BD. 5. and Tjirandji 1.

(2) In the accompanying table (II) the actual yield records obtained in commercial tapping of budded areas on "X" estate are given. Unfortunately, no exactly comparable seedling areas were tapped for comparison but, from estate records, it is shown that the average yield of good seedling rubber on very similar soil is about 500 pounds per acre at maturity.

Block A contains 70 per cent. buddings of the 2nd class clones AVROS 33, 36, 52 and 80; 20 per cent. seedlings and false buddings; 10 per cent. of clones AVROS 49 and 50 which are now considered 1st class clones.

Block B contains 50 per cent. buddings of clones AVROS 49 and 50; 40 per cent. of 2nd class clones as above and 10 per cent. false buddings.

It should be clearly appreciated that, although the clones AVROS 33, 36, 52 and 80 are described as second class clones they are by no means useless or complete failures. This is clearly borne out by the actual yield figures recorded in the attached table. There appears to have been a good deal of misunderstanding on this point. Because a clone which has been recommended for use in the early days of budding is no longer recommended it is not correct to infer that the clone has developed such defects that the buddings are now useless. At their worst, they are likely to be more productive than normal good seedlings. The correct inference is that selection work is still progressing and the oldest selections are constantly being improved upon.

In the accompanying table the yield for Block B shows that there is a reasonable expectation of reaching a yield of 900 to 1,000 pounds per acre in the 3rd year of commercial tapping.

TABLE II

Yields from budded areas containing AVROS clones in mixed planting. Age at commencement of tapping 5 years

Month of Tapping System :—Daily Tapping in alt. months.	Block A 110 acres Yield per Acre lbs.	Block B 78 acres Yield per Acre lbs.
1930 1931		
December — January	33.3	37.4
February — March	32.9	41.7
April — May	52.6	52.3
June — July	55.2	64.8
August — September	68.5	77.7
October — November	56.4	77.7
Total pounds per acre.	298.9	351.6
1931 1932		
December — January	75.5	94.0
February — March	80.6	102.9
March — April	62.0	75.2
May — June	80.3	101.9
July — August	96.1	114.5
September — October	86.1	116.7
Total pounds per acre.	480.6	605.2
1932 1933		
November — December	91.7	112.6
January — February	109.1	138.2
March — April	122.4	153.6
May — June	94.9	111.0
Total to date (8 months) pounds per acre	418.1	515.4

The budded areas from which these figures are obtained were established in September 1925 and heavily supplied in April 1926.

(3) On the same estate, monoclone plantings of clones AVROS 49 and 152 have been in tapping for 3 years. The relative yields have been summarised in Table III on p. 143.

(4) In Table IV, the results obtained on a number of estates, where commercial tapping of budded trees is in progress, are summarised.

(5) In the Prang Besar Estate pamphlet for 1933 (issued on 15th April 1933) in Table II a comparison between the yields of seedlings and buddings of the second vegetative generation of some

TABLE III

Tapping:—Alternate daily on half circumference

Clone	Yield in pounds per acre per annum (100 trees per acre)		
	Age 5 to 6 yrs.	Age 6 to 7 yrs.	Age 7 to 8 yrs.
AVROS 49	446	695	1,180
AVROS 152	443	661	1,420

TABLE IV

Clone	Area (acres)	Age (years)	Yield per annum	
			pounds per acre	pounds per tree
Clones BD. 2, 5, & 10 mixed	55½	6	404	4.0
Clones AVROS 36—other AVROS clones	267	6	337	4.2
AVROS 36 monoclone	121	7	543	7.7
AVROS clones mixed	42	7	427	5.2
H.A.P.M. clones	5½	9	1103	11.0
* (untested)		10	1450	14.3
H.A.P.M. clones * (untested)	200	10	1000	10.3
Older proved clones	not quoted	9	1361	12.5

* Untested indicates that the buddings were established direct from very carefully selected mother trees.

of the P.B. clones is given. The relationship between the yields of seedlings and buddings is much the same as that found for the AVROS clones quoted above.

(6) On one estate in Malaya, clone X (a local Malayan clone of average merit) has yielded for the first three months of tapping at the rate of 530 pounds per acre over a monoclone planting of 56 acres. The buddings are now just 5 years of age from the date of budding.

To sum up, the figures so far available from commercial tapping confirm the results of the early experimental tests on small numbers of trees. Although it appears hardly likely that we shall reach the maximum yield in practice indicated by the results of test tapping it seems probable that yields rising from 450 pounds per acre at the sixth year of age to at least 1,500 pounds per acre at maturity will be obtained from the modern budded plantation.

Acknowledgement

The figures given in the first example are taken from published papers by Dr. C. Heusser of the AVROS Experiment Station, Sumatra.

Acknowledgement is also made to the managers of estates who have sent us results of the tapping tests and records from which these notes have been compiled.

C. E. T. M.

A NOTE ON TRANSPLANTING OF BUDDED STUMPS OF HEVEA

BY

L. E. Morris *

In the Annual Report of the Botanical Division for 1931 (1) reference was made to the preliminary results of an experiment on the influence of the retention of lateral roots on the shooting of budded stumps. Observations were continued into 1933 and the results can now be given in more detail.

Ostendorf in 1931 (2) published observations on the development of young Hevea buddings in Java. A series of seedling stocks was budded with clones A.V.R.O.S. 50 and Cultuurtuin 88. One-third was left undisturbed, one-third dug up immediately after cutting back and replanted with as many lateral roots as possible, and the remainder replanted after the removal of all lateral roots. The buds on the undisturbed plants were the first to shoot and those on the stumps transplanted without side roots were the last. For both clones the time taken for half the buds to shoot was about 10 to 14 days shorter for the stumps with lateral roots. The progress of shooting of both clones is shown in Fig. 1.

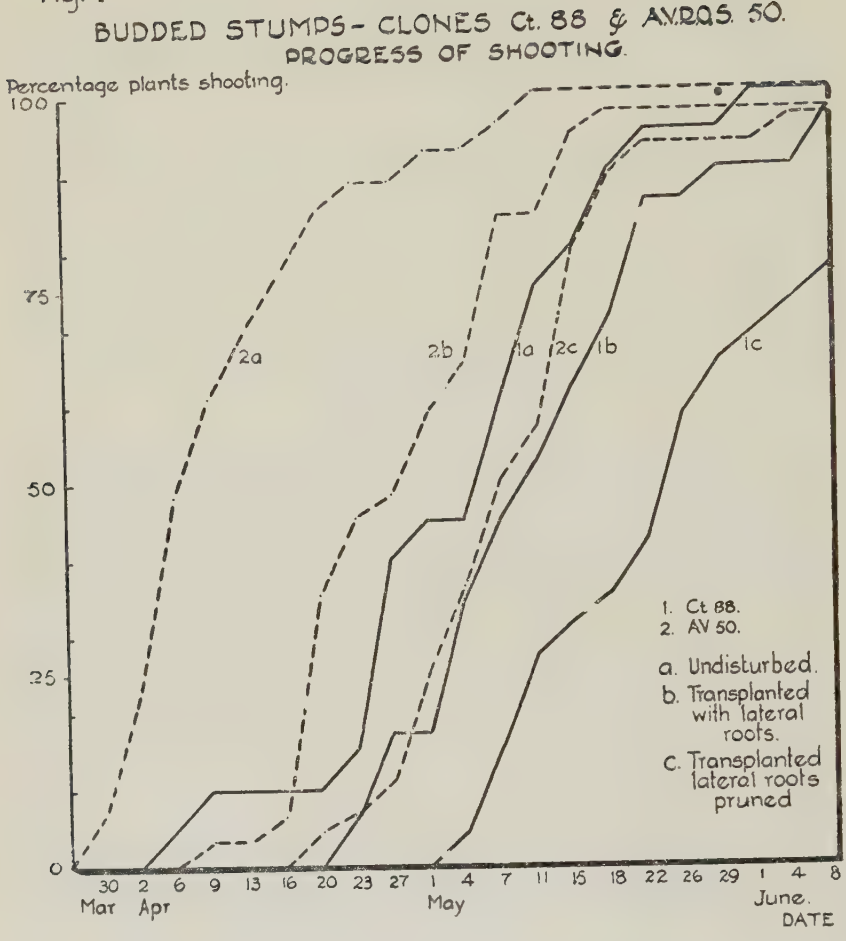
Such a difference in the rapidity of shooting of budded stumps after transplanting, especially if the advantage is maintained in the subsequent growth of the shoots, may be of great importance if budded stumps have to be transplanted late in the season or shortly before a period of dry weather. It was therefore considered desirable to follow up Ostendorf's results under Malayan conditions.

Experimental Material and Methods

Seedling stocks of mixed origin about 20 months of age, were budded between the 7th and 16th September 1931 with buds from clones A.44 and B.84 (Pilmoor) and clone A.V.R.O.S.50. Bandages were opened on the 1st October and the stocks of successful buddings were pruned off at a height of 4 inches above the grafted buds on October 13th 1931. Following our standard practice for planting of budded stumps, the buddings were allowed to remain undisturbed

* The work described in this paper was initiated by Mr. L. E. Morris and the report has been drafted by him. The final measurements and the completion of the report has been undertaken by members of the Staff of the Botanical Division.

Fig. 1



(After Ostendorf)

for a period of 10 days in order that the pruning cut (snag) might become partially healed and the grafted bud stimulated and swollen in preparation for shooting. On October 23rd and 24th the buddings were carefully dug up and prepared for immediate transplanting. The budded stumps were divided into three groups; in one set all lateral roots were completely removed, in the second the laterals were cut back to six inches from the tap root, and the third group was left with twelve inches of side roots which in many plants included a good deal of fibrous root. The planting holes had already been prepared so that filling and transplanting were carried out in one operation, treading the soil in firmly and taking care to keep the lateral roots horizontal as far as possible.

The numbers of the stumps of the three clones and three groups of root lengths are shown in Table I.

TABLE I

Numbers of budded stumps transplanted

CLONE	Lateral Root Length		
	12 inches	6 inches	0 inches
A.V.R.O.S. 50 ...	30	31	27
Pilmcor A. 44 ...	17	19	19
Pilmoor B. 84 ...	26	22	21
Tota (all clones) ...	73	72	67

Results

Observations on the shooting of the buds and measurements of the length of the scion shoots were started two weeks after planting, and continued twice a week until the beginning of January 1932. Later inspections and measurements were made during February and November 1932.

1. *Observations on the influence of the severity of the initial root pruning on the rate of shooting of transplanted budded stumps*

The rate of shooting can be considered in two ways, either as the mean time taken for all the buds to shoot or as the number of buds shot in a given time. The results of the observations are set out in Tables II and III. In some plants the production of an actual shoot was considerably delayed beyond the first signs of breaking of the bud, and for these a mean time has been taken.

TABLE II

Comparison of rates of shooting of grafted buds
Mean time taken, in days, for all living plants to shoot

CLONE	Lateral Root Length		
	12 inches	6 inches	0 inches
A.V.R.O.S. 50 ...	29.7 days	25.5 days	28.2 days
Pilmoor A. 44 ...	19.6 „	20.7 „	26.3 „
Pilmoor B. 84 ...	25.0 „	25.1 „	40.7 „
Mean (all plants) ...	25.9 „	24.5 „	34.0 „

The results summarised in Table II show that on the average, the stumps with lateral roots shot from 8 to 10 days earlier than those without. The difference is most marked in clone B. 84 and least in A.V.R.O.S. 50 in which the stumps with long lateral roots took as long to shoot as those with no lateral roots.

The standard errors of the mean times of shooting are given below, together with the greatest difference between stumps with roots and no roots and the standard error of that difference. For clone A.V.R.O.S. 50 the difference is less than its standard error, and for clones Pilmoor A.44 and B.84 the differences are about 1.5 and 1.9 times the standard errors. None of these differences is completely significant when taken alone, but all are in the same direction and the total result can be regarded as significant.

Clone	Standard errors of means - days			Greatest difference roots and no roots	Standard error of that difference
	Root lengths				
	12 ins.	6 ins.	0 ins.		
A.V.R.O.S. 50	3.0	2.4	2.3	2.7	3.3
Pilmoor A. 44	1.5	1.9	4.3	6.7	4.6
Pilmoor B. 84	3.8	6.2	4.0	14.4	7.4

Table III

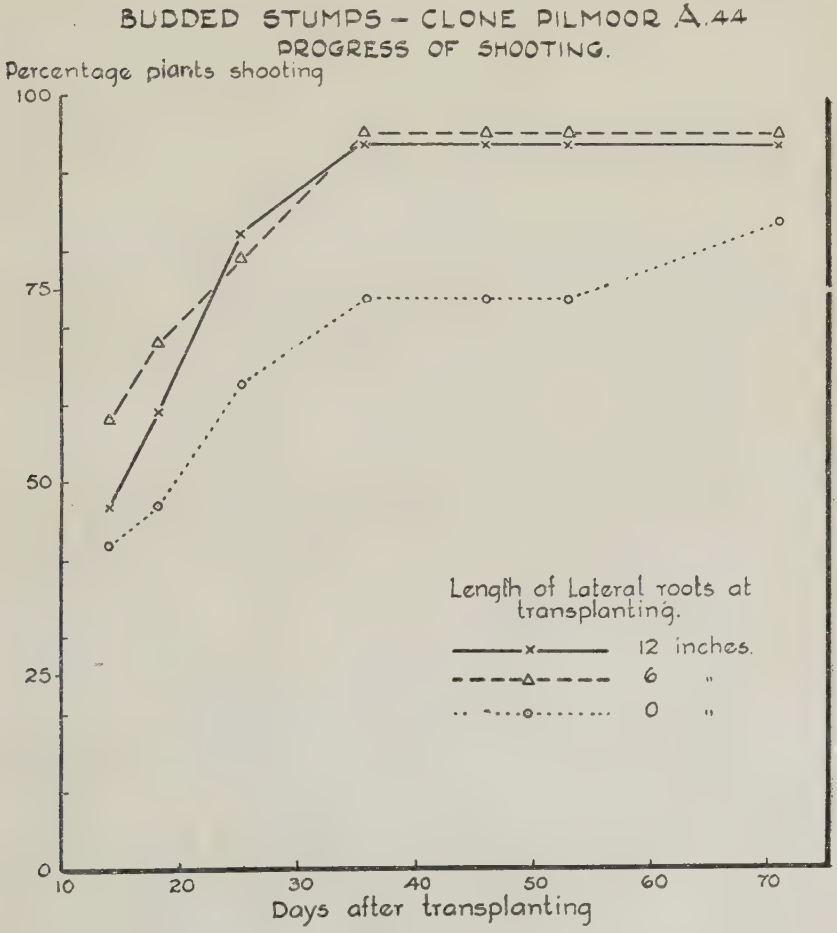
Comparison of rates of shooting as shown by percentage of stumps shot after 25 and 53 days from transplanting

Clone	After 25 days Lateral root length			After 53 days Lateral root length		
	12 ins.	6 ins.	0 ins.	12 ins.	6 ins.	0 ins.
A.V.R.O.S. 50	50	71	41	80	94	96
Pilmoor A. 44	82	79	63	94	95	74
Pilmoor B. 84	50	55	19	73	91	76
Mean percentage of all plants	57	68	40	81	93	84

Table III shows the numbers of buds that had shot on November 17th and December 15th at 25 and 53 days after transplanting. At the earlier date the plants that had retained their lateral roots appear to possess a clear advantage over those that have been completely root pruned. Later, the differences shown are very small.

Observations taken at four months from the date of planting showed no significant differences between the final percentages of buds shot. At this time the percentage number of successful plants in the three classes was 88, 96 and 93 for buddings with long, medium, and no lateral roots respectively. The progress of shooting in clone A.44 is illustrated in Figure 2.

Fig. 2



2. Observations on the influence of the degree of root pruning at planting and subsequent growth

The next point to be examined is whether early shooting produces a permanent effect on subsequent growth and in Table IV the mean lengths of the scions on 22.12.31, 19.2.32 and 3.11.32, i.e., at two, four and twelve months after transplanting, are summarised.

TABLE IV

Comparative rates of growth of scions of budded stumps planted with different lengths of lateral roots. Records of mean growth in height of scions measured in inches

CLONE	Initial Length of Lateral Roots in inches		
	12 inches	6 inches	0 inches
A.V.R.O.S. 50	15.0	15.7	11.5
Pilmoor A. 44	10.5	10.3	7.7
Pilmoor B. 84	17.2	19.3	10.1
*Mean height at 2 months	14.8	15.4	9.9
A.V.R.O.S. 50	31.8	30.4	22.9
Pilmoor A. 44	24.2	20.3	16.3
Pilmoor B. 84	33.8	32.6	21.0
*Mean height at 4 months	30.6	28.5	20.7
A.V.R.O.S. 50	130	125	97
Pilmoor A. 44	76	66	50
Pilmoor B. 84	114	112	83
*Mean height at 1 year	112	106	81

* Note :—The mean heights for each period are calculated from the total growth of all buddings irrespective of clone.

The figures given are the means for the stumps that had shot; those with dead or still dormant buds are not included. The records show a clear superiority in growth of the stumps transplanted with lateral roots over those without. At both of the first two measurements the average shoot length is 50 per cent. greater and after a year it is still 30 per cent. greater. The actual difference has increased from 5 to 10 inches between the first two measurements and to 30 inches between the second and third measurements. It is evident that the initial advantage of earlier shooting is reflected in the more rapid growth of the scions during the first year.

Statistical examination of the detailed figures shows that the standard errors of the means for scion growth in clone A.V.R.O.S.50 on February 19th 1932 are 1.5, 1.3 and 1.9 respectively. Thus the growth of buddings transplanted with lateral roots is significantly better than the growth of plants whose lateral roots have been completely removed before replanting. There is no significant difference in growth between the plants retaining lateral roots 6 inches long and those retaining lateral roots 12 inches long. In November 1932 the difference in shoot length between the groups transplanted with 12 inch lateral roots and those with no lateral roots was 33 inches and the standard error of this difference was 8.25 inches. This difference is therefore fully significant.

When the final observations were taken in June 1933 the percentage of vigorously growing buddings was greatest in the group transplanted with lateral roots pruned to six inches. The actual figures were 12 inch lateral roots, 92 per cent.; 6 inch lateral roots, 97 per cent.; no lateral roots, 87 per cent.

Conclusions

Under the conditions of this experiment it is demonstrated that, in the practice of transplanting budded stumps, the retention of lateral roots has a decidedly beneficial effect on the rate of shooting and subsequent vigour of growth of the scions during the first two years.

Fewer deaths occurred when lateral roots were retained at transplanting.

For large scale operations the difficulty of transplanting budded stumps with large amounts of lateral root is appreciated so that when large budded areas are being developed the initial budding work is generally carried out on seedling stocks established in the field. For the subsequent supply-planting of failures the method described in the present communication can be recommended.

Literature Cited

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OBSERVATIONS ON THE COMPLETION OF THE UNION IN BUDDINGS OF HEVEA BRASILIENSIS MADE ON LARGE STOCKS

BY

C. C. T. Sharp

In the course of field budding operations on the R.R.I. Experiment Station observations have been made on the healing-over process at the pruned surfaces of the stocks or "snags" of budded trees. Particular attention has been paid to buddings made on very strong stocks over two years of age and in this paper, an account of the observations is recorded.

In the past attention has usually been paid to the application of fungicides and the prevention of 'die-back' of the snag. In the present case further observations on the application of wound dressings have been made but more particularly the effect on callus growth of the slope of the pruning cut has been studied.

First Series of Observations

An experimental block, (R.R.I. Experiment Station, Block 10), ten acres in extent and containing 900 seedling trees was divided into five strips, each strip being budded in October 1931 with a different clone. The clones used were Bodjong Datar 5, AVROS 152, Sungei Reko 9, AVROS 50 and Prang Besar 186. Equal numbers of trees of each clone were budded at ground level and at heights of one, two, three and four feet above ground level. At the time of budding the seedling stocks were 2 years and 10 months of age.

The mean girth at the time of budding was 12.5 inches at the collar. Trees of less than 9 inches circumference are not included in these records.

In March 1932 the stock 'snags' on all trees which showed two feet of brown wood at the base of the scion were pruned back to the level of the point of attachment of the scion and the pruned surfaces were treated with a 20 per cent. solution of "Agrisol" followed by a mixture of asphalt and kerosene in the proportion of two of asphalt to one of kerosene.

At the end of July and the beginning of August 1932 the snags not pruned in March were also cut back. It was noticed that some of the snags pruned in March were showing only a partial growth of callus. At the same time, over a part of the circumference, usually on the side opposite to the point of attachment of the scion, dying back of the stock tissues below the level of the cut was observed.

These 'snags' were re-pruned by cutting with a saw along a plane passing through the points on the left and right sides of the cut surface at which the callus reached the level of the snag, and the upper limit of the living tissue on the side opposite to the scion. The roughly sawn surfaces were pared smooth with a large knife and painted with a 20 per cent. solution of "Agrisol". No other treatment was given.

The Angle of Slope of the Pruning Cut

It was observed that the trees with the steepest cut had produced the greatest growth of callus; consequently in July pruning was in general carried out at a steeper angle than in March.

The angle at which the pruning cut was made and the proportion of trees requiring re-pruning are shown in Table I.

TABLE I

Trees pruned in March 1932
Proportion of trees requiring repruning at varying angles of slope. 21st July 1932

Angle of slope of first pruning	Total No. of trees	Second pruning required	
		No. of trees	Per cent.
15°	1	1	—
20°	4	4	100
25°	40	25	60
30°	37	19	51
35°	29	15	52
40°	8	4	50
45°	3	1	33
Total ...	122	69	

There is a tendency for the number of trees requiring to be re-pruned to decline as the angle of the pruning slope increases.

Since the amount of callus first formed was small, it was considered that a sufficiently accurate method of recording its growth would be to measure in degrees the amount of the circumference of the snag which was covered by growing callus tissues. Thus if a complete ring had been formed above the level of the cut surface this was recorded as 360°; if the callus only reached the level of the snag round one-third of the circumference this was recorded as 120° and so on.

After the re-pruning the trees were divided into three groups for the purpose of recording callus growth at different angles of slope of the pruned surface.

Group A. Pruned in March 1932 and treated with asphalt-kerosene.

Group B. Pruned in March 1932 and treated with asphalt-kerosene. Re-pruned in August 1932 and treated with 20% 'Agrisol' only.

Group C. Pruned in August 1932 and treated with 20% 'Agrisol' only.

In Table II is shown the growth of callus of groups A and B combined in May 1932 and Group C in October, the measurements in each case being taken two months after pruning the snags.

TABLE II

Growth of callus in degrees two months after pruning

Slope of pruning cut	Groups A & B combined		Group C	
	No. of trees	Mean growth Degrees	No. of trees	Mean Growth Degrees
15°	1	90	—	—
20°	4	101	1	360
25°	40	154	8	139
30°	37	149	21	243
35°	29	174	29	243
40°	8	176	37	286
45°	3	185	31	305
50°	—	—	23	306
55°	—	—	6	302
60°	—	—	6	325
65°	—	—	3	310
Total ...	122		165	

In Table III the growth of callus is shown for each group in March 1933. The figures show the percentages of the area of the snag which still remain to be callused over. For this purpose the snag is regarded as consisting of two similar ellipses, and the area of the smaller uncallused one is expressed as a percentage of the area of the whole snag.

TABLE III

Mean percentage of the area of the snags remaining uncallused in March 1933

Slope of pruning cut	Group A		Group B 1st cut		Group B 2nd cut		Group C	
	No. of trees	Mean	No. of trees	Mean	No. of trees	Mean	No. of trees	Mean
15°	...	...	1	66.0	...	...	...	...
20°	...	...	4	61.0	...	...	1	86.0
25°	13	43.3	20	54.2	1	43.0	7	73.4
30°	17	42.6	15	53.1	5	54.8	19	71.2
35°	11	23.2	12	48.3	8	56.7	22	66.1
40°	3	22.7	4	45.7	10	47.6	32	68.3
45°	2	23.0	3	41.0	12	50.3	30	58.3
50°	...	...	...	...	7	52.0	21	51.9
55°	...	...	...	...	8	55.5	6	54.5
60°	...	...	...	...	4	59.2	6	53.3
65°	...	...	...	...	3	39.0	1	54.0
75°	...	...	...	...	1	64.0	...	...
Means and Totals	46	36.0	59	52.0	59	52.0	145	56.2

Note: Group B is arranged in two ways: firstly according to the angle of the cut at the first pruning and secondly according to the angle of the new cut after re-pruning in August 1932.

Discussion

From the figures in Table III recording callus growth in Group C for March 1933, the correlation between angle of slope and the percentage of the snag area remaining uncallused was found to be −.386. It is clear that the percentage of callus growth must also be in part proportional to the area to be covered over and the figure of −.386 can only be relied on if it can be shown that the angle of the pruning slope tended neither to increase nor decrease with an increase in the area of the snag. Further examination of the figures showed that this was not the case and that there was a tendency on the part of the labourers employed in pruning to make a flatter cut on a large stock than on a small one, due to the practical difficulty of using a saw at a steep angle near the ground and to the rapid increase in girth of the stocks as the base of the tree was approached. The correlations and partial correlation for slope of pruning cut, area of snag and percentage uncallused are given in Table IV.

TABLE IV

	Mean	Standard deviation	Coefficient of correlation	Partial correlation
1. Angle of slope	43°	8.9°	r_{12}=−.3860	$r_{12\cdot3}$=−.2554
2. Percentage uncallused	63 per cent.	16.5 per cent.	r_{13}=−.3205	$r_{13\cdot2}$=−.1197
3. Area of snag	43 sq. ins.	12.0 sq. ins.	r_{23}=+.6015	$r_{23\cdot1}$=+.5471

The negative correlation of −.2554 is fully significant. A similar calculation was made for Group A, the coefficients of correlation and partial correlation being —.4080 and —.2419 respectively showing very close agreement with Group C. From this it may be concluded that there is a definite tendency for a steep pruning cut to produce more rapid growth of the callus tissue over the snag. Reference to Table III indicates that the optimum angle lies at about 50°. Typical specimens showing the effect of the angle of the pruning cut are illustrated in Plates 1 and 2.

Second Series of Observations

An experimental area (R.R.I. Experiment Station, Block 14B) consisting of mixed buddings of clones established from hand pollinated seedling trees with control trees budded with clone AVROS 50, was used for a further series of observations. Budding was carried out from 14th to 16th October 1931 when the stocks were two years of age and the "snags" were pruned at an angle of 45° on 17th to 20th August 1932. Observations of callus growth were taken on ten rows of 20 trees. Alternate rows were left untreated after pruning, the remainder being treated with a 20 per cent. solution of "Agrisol" followed by the standard asphalt-kerosene mixture in the proportion of two parts of asphalt to one part of kerosene.

The percentage of the snag remaining uncallused was measured in the manner already described for the later measurements in the first series. Measurements were made at intervals of approximately two months, the means of each of the ten rows being calculated separately. The results are set out in Table V and expressed by means of a graph in Fig. 1.

TABLE V

Record of Callus Growth. Block 14B

		Mean percentage of snag uncallused					
	Date	26.10.32	6.1.33	24.2.33	16.5.33	26.7.33	11.12.33
Untreated	Row 1	62.95	51.26	38.10	20.67	8.06	0.00
	4	61.85	49.84	41.10	31.55	17.16	11.90
	7	64.15	53.90	46.70	31.20	15.85	3.55
	10	56.90	44.90	35.66	21.74	11.79	4.79
	13	58.35	39.30	34.10	17.68	8.32	4.74
	Mean	60.84	47.84	39.13	24.57	12.22	5.00
	Standard deviation	3.09	5.79	4.99	6.39	4.20	4.32
Treated with Asphalt—Kerosene Mixture	Row 2	74.75	57.45	49.25	40.53	30.21	20.36
	5	65.70	53.00	45.10	37.65	25.45	11.50
	8	65.90	51.50	44.90	34.90	21.85	8.95
	11	68.00	54.65	50.89	44.37	30.94	17.84
	14	64.60	52.55	48.25	40.00	22.70	5.10
	Mean	67.79	53.83	47.68	39.49	26.23	12.75
	Standard deviation	4.08	2.32	2.62	3.52	4.19	6.29
Difference Treatment – Control		6.95	5.99	8.55	14.92	14.01	7.75
Standard error of difference		2.29	2.79	2.25	3.26	2.65	3.41

The percentage of trees of which the snags were completely callused over at the different times on which the observations were made is shown in Table VI.

TABLE VI

Percentage of trees completely callused over

Dates	26.10.32	6.1.33	24.2.33	16.5.33	26.7.33	11.12.33
Untreated	0	1	3	15	39	82
Treated	0	0	1	15	27	68

DYING-BACK OF THE SNAGS

No attempt was made to measure the amount of die-back of the cut surface of the snags. On small stocks this is not, in the opinion of the writer, a matter of great importance. If the callus is growing vigorously the cavity formed by the dying-back of the stock tissues is filled rapidly by an ingrowth of callus from the sides in the manner shown in Pate III.

Discussion

A difference of twice the standard error is usually regarded as significant. It may therefore be concluded that the growth of callus in the untreated rows was definitely better than in the asphalt-kerosene treated rows. The advantage was apparent two months after cutting back the snags and it increased steadily for nine months by which time three quarters of the total area to be healed had been covered over by callus growth. Reference to the Graph in Fig. 1 shows that the growth of the callus of the untreated rows was steady and not appreciably affected by the varying weather conditions experienced between October and May. On the other hand the rate of growth of the callus in the treated rows declined slightly during the months immediately after wintering. It is suggested that this is due to the high temperatures reached on the black surface of the treated snags.

Summary

1. Observations on the effect of the angle of the pruning cut on the rate of callus growth of budded trees are recorded.

2. An account is given of an experiment to test the value of the standard asphalt kerosene mixture as a dressing for the pruned surfaces of the stocks of budded trees.

I am indebted to Mr. H. Gunnery for the photographs from which the plates appearing in this paper have been prepared.

Plate 1. Poor uneven growth of callus. Pruned at an angle of 35°. Untreated.

Plate 2. Vigorous growth of callus. Pruned at an angle of 50°. Untreated.

Plate 3. Treated with Asphalt-Kerosene. Centre decayed with callus growing in from the sides.

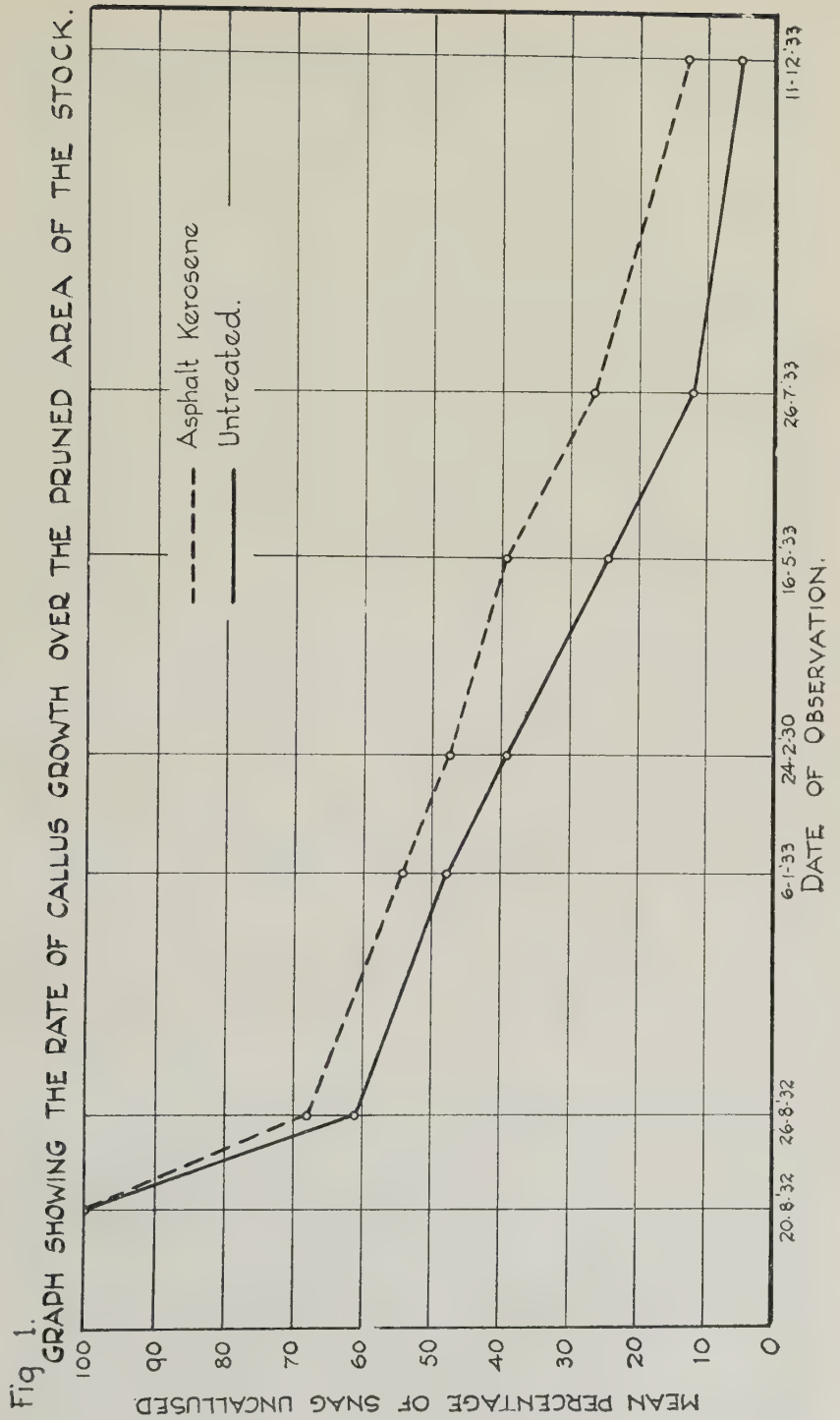


Fig 1.
GRAPH SHOWING THE RATE OF CALLUS GROWTH OVER THE PRUNED AREA OF THE STOCK.

EXPERIMENTS IN CONTROL OF THE TERMITE PEST OF YOUNG RUBBER TREES

BY

F. Beeley

Some time ago considerable criticism arose as to the suitability of Paris Green dust for the control of White ants; it was alleged that considerable damage by bark burning had been noticed in many cases; it was also alleged that the application of Paris Green to the bark of the tap root of a tree increased its susceptibility to a certain type of root disease *(Sphaerostilbe repens)*.

As a result of this criticism a questionnaire was circulated to all estate managers who were known to be using Paris Green. The information derived from this questionnaire may be summarised as follows:—

1. In ordinary well drained soils Paris Green will efficiently and cheaply control the white ant pest of rubber trees of all ages if a suitable method of inspection and treatment is adopted.

2. There is no evidence of damage done to the bark by Paris Green unless excessive quantities are used; such damage applies more especially in wet acid soils.

3. It is possible that any damage may be avoided by mixing the Paris Green with hydrated lime in equal proportions.

4. There is no foundation for the suggestion that treatment with Paris Green causes or predisposes towards the incidence of *Sphaerostilbe* root disease.

5. Severe attacks of this root disease in previous years have been found to be a direct consequence of flooding of rubber areas.

6. The fungus *Sphaerostilbe repens* and termites, by reason of their similar habitats, have been found in association, while the association of this fungus with Paris Green does not hold.

Experiments showed that as much as 4 ozs. per tree in dry situations and 3 ozs. in wet situations could be applied without killing the tree, though slight bark damage occurred at the junction of lateral roots with the tap root and around wounds caused during the root exposure operation. Other arsenic compounds were found to have the same effect when applied to the roots in this excessive quantity. The addition of hydrated lime to these insecticide dusts slightly reduced this tendency to burn the bark The margin of safety is however sufficiently great as the recognised amount to apply is from $\frac{1}{4}$ oz. to $\frac{1}{2}$ oz. according to the size of the tree, and degree of infestation.

The chief source of danger lies in the actual process of dusting. If powder falls in lumps on the roots, the bark is burned locally. Attention to ensure efficient dusting is therefore a prime factor in this method of treatment.

During these investigations a search was made for alternative methods of control of the termite pest.

With the help of Mr. Tilley of Imperial Chemical Industries and Mr. Westrop of Malayan Fertilisers Ltd. it was possible to design an experiment to try various insecticides giving a range of effects viz. fumigants, contact poisons, stomach poisons and concussion death by explosive gases.

An area of 3 year old rubber trees which had suffered heavily from termite attack since planting was put at our disposal. The area was already divided by deep main drains into fourteen blocks each of approximately 4½ acres. The soil was peat over a very stiff clay, the depth of peat varying from one to three feet. The land was quite flat and even, bearing an excellent cover crop throughout. For various reasons it was decided not to include Paris Green and Perchloride of Mercury in the experiments.

Work commenced on the test blocks late in June while the majority of the insecticides were applied during the first week of July, and two inspections were made at intervals of five weeks each.

The species *Coptotermes curvignathus* Holmgr appeared to be the only offender attacking the rubber trees. *C. curvignathus* is of common occurrence in lowlying soils and shows a strong preference for damp sheltered situations such as obtains under a heavy growth of cover crop.

Though it must be admitted that an attack of root disease predisposes a tree to termite attack nevertheless there is ample proof that *C. curvignathus* will attack apparently healthy young rubber trees and, if left undisturbed, can cause the death of a tree within three or four weeks.

The seat of attack may vary considerably and may be at a point a few inches above ground or at any point below ground level. The most usual point of entry is at a fork of the taproot or near some hollow malformation of the taproot at about nine inches below soil level. As the attack is extended upwards above ground level a mud wall or casing is built round the trunk to protect the colony from other insects, birds and heat. Beneath this mud casing the bark is attacked almost at once at many points, causing exudation of latex which coagulates with the attached mud forming a rubbery mass very difficult to clean off when treatment is given.

Meanwhile the termites have been vigorously mining the tap root so that numerous long radially flattened galleries are formed

in the wood. These galleries are extensively interconnected and in time so weaken the tree that the slightest wind will blow it over.

In the case of buddings being attacked by white ants the upper limits of the mud wall may not extend beyond the union, the attack being concentrated on the snag. In heavy cover such infested trees may easily be overlooked until too late when the trees are usually blown down.

Dr. A. S. Corbet in one of his reports considers it probable that these attacks are made by occupants from a central nest which may be situated some distance under ground. The fact that the large number of "soldiers" which are found in the early stages of an attack gives place subsequently to a preponderance of "workers" indicates that communications are maintained between the termites on the tree and those in a central termitarium. The queens of *C. curvignathus* can rarely be found and there is no evidence to indicate that this species makes permanent nests in young rubber trees.

Experimental

Experiments carried out in the various plots were as follows:—

Experiment 1

Digging over to eliminate buried timber and nests.

Procedure. The cover crop was rolled up and by prodding at distances of 9 inches with long pointed iron bars the ground was explored for buried timber to a depth of over 3 feet. The buried timber indicated by flagged sticks was then dug out completely and burned. It was hoped that all the buried timber and termite nests would be removed, while attacked trees were cleaned up and their tap roots exposed to a depth of nine inches.

It might be mentioned here that charred timber was dug up from depths of 3 ft. to 4 ft. showing that this must have sunk into the swamp since the clearing was burned. Most of the timber had at one time been well mined by termites, but at the time of these experiments comparatively little timber was still inhabited. The two common types of termites found were *C. curvignathus* Holmgr. and a species of Capritermes probably *C. dolichocephalus*, O. John, both of which were found nesting in the soil.

It was hoped that, by digging over and removing timber and nests, an area might be cleared of the pest, but actually few nests were found and these contained extremely small colonies.

Owing to the high costs of the digging, in this method of treatment, only half the plot was completed.

Results. Reference Table I. Plot 1

Though a fair degree of control has been obtained, the number of new cases is very high. The disturbance caused by this method of treatment seems to have caused the termites to migrate and reform colonies to attack other healthy trees.

EXPERIMENT 2

Infested zones, as indicated by attacked trees, were dug over to the clay subsoil, removing and burning all timber, tracing out galleries and destroying nests. This method is very similar to (1) but less extensive and less expensive.

Results. Reference Table I. Plot 2

It will be noted that 60 per cent. of the original active cases have recurred up to the 10th week after treatment and the number of new cases equals 100 per cent. of the original; this is a very poor result.

EXPERIMENT 3

Termite infested zones, as indicated by attacked trees, were explored with rods; galleries or nests were located and about 25 ccs. (about one ounce) of Carbon bisulphide poured into the hole leading to a gallery. After waiting for five to ten minutes for the liquid to vapourise and penetrate the galleries a lighted match was dropped into the hole thus causing an explosion, said to be sufficient to kill the termites by concussion.

Undoubtedly termites near the seat of ignition were killed either by the original gas, the explosion or by the gases remaining after the explosion. If a large underground system of galleries was located carbon bisulphide was injected at two or more centres. All infested trees were cleaned to a depth of 9 inches in the soil.

Results. Reference Table I. Plot 3

It will be noted that although 50 per cent. control has been obtained over the known cases, the increase in number of new cases is 100 per cent. indicating that colonies of termites have reformed and passed on to neighbouring trees.

EXPERIMENT 4

All trees were opened up to a depth of one foot and lateral roots exposed to a distance of one foot from the bole. Calcium

arsenate powder was then lightly dusted on to the bole, tap root, laterals and soil in the crater. Infested trees were cleaned up and dust blown into the mass of mud and termites collecting in the hole. The supplies, mostly too small to be opened up in this area, were trenched round to a depth of one foot at a distance of 2 feet from the plant. Dust was then lightly blown into the base and walls of the trench.

These holes and trenches were not filled in until after a period of 5 weeks, the latest time at which a second treatment should have been given.

The amount of powder used averaged about $\frac{1}{8}$ oz. per tree.

Results. Reference Table I. Plot 4

This method of treatment gave over 90 per cent. control on the first round of inspection and 65 per cent. control over the ten week period which is considered extremely good, and it seems possible that two or three such rounds of treatment should banish white ants from heavily infested clearings such as this. The cost for labour ($2.50 per acre) is rather heavy, and was due to the dry weather during the first few days of the experiments when the labourers found difficulty in digging through the baked peat and clay. After rain similar opening up was done for about $1 per acre or 45-50 trees per labourer per day.

EXPERIMENT 5

The area was mechanically treated as in the case of Plot 4 but Sodium silicofluoride powder was the insecticide dust used. The costs are very similar to Plot No. 4. Again about $\frac{1}{8}$ oz. of dust per tree sufficed.

Results. Reference Table I. Plot 5

Like the previous insecticide dust Sodium silicofluoride has given excellent control, especially when it is realised that there were over 90 recently supplied stumps mostly replacing trees killed by white ants and therefore still potential danger zones.

It is apparent, however, that repeated applications of the powder will be necessary to effect complete control.

The appearance of 19 new cases at the 10th week is not so good as was desired.

EXPERIMENT 6

This area was demarcated into infested zones as indicated by the supplies and present infested trees. Trees within these

zones were then opened up to a depth of 9 inches and a proprietary fumigant meal known as "Seekay" was applied at the rate of two ounces per tree, admixed with a little soil then covered over with soil so as to retain the poisonous gases. All attacked trees were thoroughly cleaned from termite mud walls, latex and soil debris normally found adhering to such trees.

Results. Reference Table I. Plot 6

The results obtained by this method are quite good; the number of old cases recurring being only 13 out of 46 originally attacked. The appearance however of 33 new cases indicates that more than one ring of neighbouring trees must be treated at the same time as the attacked one.

EXPERIMENT 7

All trees were opened up to a depth of 6 inches to a distance of 9 inches from the bole. To each tree was applied two gallons of a solution of Calcium cyanide (Cyanogas dust). This solution rapidly gives off hydrocyanic acid gas and should always be prepared on the spot. In practice a 4 gallon bucket is filled with water and two level tablespoonfuls of the powder added, stirred and at once applied to the base of the tree, one such bucket being sufficient for two trees. This solution caused immediate death to all termites present in the bole or tap root of the tree.

Results. Reference Table I. Plot No. 7

Although an apparently large number of new cases have appeared since the cyanide treatment the early effects are good in that none of the old cases reappeared in the first five or ten weeks. This again shows a possibility of dealing easily with a heavy infestation by means of two or three rounds of treatment. Water was very handy on the clearing so that labour costs were low.

EXPERIMENT 8

Trees in infested zones only were treated with Carbon bisulphide jelly. This jelly is made by treating small pieces of dry rubber clippings with Carbon bisulphide in the proportion of one pint of fluid to one pound of dry rubber. The rubber absorbs the fluid to form a soft jelly-like mass. Three to four pieces about the size of a walnut were then dibbled in close to the tree to a depth of 6-9 inches. Carbon bisulphide gas, which is slowly evolved from the jelly, poisons the termites. The components of

the jelly may be varied to make easy handling in the field. All infested trees were opened up to a depth of nine inches and thoroughly cleaned of debris.

Results. Reference Table I. Plot No. 8

The results are rather poor; although 60 per cent. control of affected trees has been obtained the appearance of 31 new cases in the block indicates that the fumigant has merely driven the termites to other untreated trees. The experiment is however worth repeating but all trees in the block should be treated.

Experiment 9a

One half of the area of Plot 9 was treated tree by tree with a similar rubber jelly containing Orthodichlorbenzene. The jelly was dibbled in to a depth of 9 inches and the hole closed over with the heel. Although very few active cases of termites were recorded at the time of treatment the plot had been heavily infested as indicated by the number of recent supplies.

Results. Reference Table I. Plot No. 9a

This experiment definitely indicated the advantage in treating all trees irrespective of their condition. Though the original number of infestations was very small, the fact that not a single old case has reappeared in 10 weeks nor any new cases developed indicate that control can be obtained cheaply by treating every tree in the area.

Experiment 9b

This half of Plot 9 was treated as for Plots 4 & 5 except that a proprietary poison known as "Cyanomag" was the insecticide used. Every tree in this half of the plot was opened up and dusted.

Results. Reference Table I. Plot No. 9b

The effect of the treatment is excellent; though there were only 6 active cases at the time of treatment there were 43 infested zones where supplies had been planted.

Experiment 10a

A further type of rubber jelly fumigant prepared as for Plots Nos. 8 & 9a, using Trichlorethylene, was tested in Plot 10a. This was dibbled in round all trees in this plot. This jelly was very stiff and was difficult to separate into small bits for dibbling in.

The addition of a little more Trichlorethylene would have rendered it a little less viscous.

Results. Reference Table I. Plot No. 10a

Here again the result is excellent but unfortunately the original infection was very light.

Experiment 10b

In this half of Plot 10 all trees were opened up to a depth of 6 inches and a dessert spoonful of crystalline Paradichlorbenzene was scattered round near the trees and the soil replaced in the hole.

Results. Reference Table I. Plot No. 10b

Unfortunately there was no direct evidence that active colonies of termites were attacking the trees at the time of treatment; there were however a fair number of supplies. The plot has remained free of white ants since treatment.

Plot 11. This area received no treatment owing to the small number of attacks.

Experiments 12 & 13

Part of Plot 12 and the whole of Plot 13 were opened up to a depth of 6 inches round each tree and into the shallow circular trench so formed was placed about 1¼ lbs. of Castor Seed Meal and the trunk left open. Castor Seed Meal is a stomach poison containing a poisonous protein. It also has an appreciable manurial value.

Results. Reference Table I. Plot No. 12

This shows an 80 per cent. control of the infested trees and an appearance of only 5 new cases per acre over the 10 week period, which is a very good result.

Experiment 14

Plot 14. *Control.* This plot was not treated in any way except that all attacked and suspected trees were opened up to a depth of 6 inches thoroughly cleaned and the soil at once replaced. In this way the number of active cases of termite attack at the time of treatment of other blocks was determined. Often, early attacks could be determined only by opening up in this way.

Results. Reference Table I. Plot No. 14

This result indicates a normal increase of 50 per cent. in the number of cases occurring after a lapse of ten weeks in areas where no form of insecticidal treatment is carried out.

Conclusions

Owing to the difficulty of obtaining plots of suitable size under similar conditions and with the same degree of infestation by termites the results vary a great deal from plot to plot. For example, the results in Plot 4, where 7 cases recur out of an initial number of 79 active cases, after dusting with calcium arsenate, are considered to be of greater value than the results in Plot 10 where there were no recurrent cases out of an initial number of only 2 active cases after treatment with fumigant rubber jellies.

An estimation is given in Table I of the results to be expected for the various treatments represented as the number of re-attacked trees and new cases appearing after 10 weeks from treatment (a) per plot of 500 trees (including supplies), (b) per 100 diseased trees and (c) per 100 infested tree spaces indicated by number of diseased trees plus number of recent supplies.

In Table II a summary is given of the general results to be expected from the use of various methods of control. It is indicated that the efficiency of these methods lie in the following order of merit.

(1) Opening up of roots and applying insecticidal dusts.

(2) Dibbling in around the base of the tree a small quantity of fumigant rubber jelly.

(3) Castor Seed Meal placed in a shallow trench round all trees.

(4) Use of explosive gases to kill the termites by concussion.

(5) Digging to eliminate buried timber and nests.

No method of treatment will at once eradicate the termite pest; a carefully planned campaign involving monthly inspection and treatment of affected areas must be carried out in order to effect a reasonable degree of freedom from this pest. The thoroughness with which the treatment is performed is more important than the type of insecticide applied.

I am indebted to Mr. Gopal of the Pathological Division for his valuable assistance in supervising the work and in making records of progress of the experiments.

My thanks are also due to the estate managers for their assistance and kindly interest in the work.

TABLE I

Plot No.	Total No. of trees	Supplies	White ant cases	No. of trees treated	Treated 1st – 7th July 1933		Quantity used	Cost of labour	Results						Cases in 10 weeks per plot of 500 trees		Cases in 10 weeks per 100 diseased trees		Sum of supplies and active cases	New cases and reattacks per 100 infested tree spaces	
					Nature of Treatment				Inspection on 10.8.33 cases appearing up to the 5th week		Inspection on 14.9.33 Further cases appearing up to the 10th week		Total up to 10 weeks								
									Old	New	Old	New	Old	New	Old	New	Old	New	—	Old	New
1	175	59	17	All	Exploring and digging out buried timber		—	67.60	3	12	0	5	3	17	5	25	18	100	76	4	22
2	403	94	48	„	do. near infected trees only		—	25.06	29	13	1	35	30	48	30	48	63	100	142	21	34
3	404	72	29	29	Explosion of carbon bisulphide		1 gal.	1.59	14	14	0	12	14	26	15	27	48	90	101	14	26
4	460	32	79	All	Calcium arsenate dust		3½ lbs.	11.53	3	4	7	14	10	18	10	18	12.5	24	111	9	16
5	432	91	66	„	Sodium silicofluoride dust		3½ lbs.	13.52	5	2	4	19	9	21	9	21	13.5	32	157	6	14
6	382	91	46	160	Seekay fumigant meal		20 lbs.	12.73	13	19	0	14	13	33	14	36	28	72	137	10	25
7	443	40	12	All	Calcium cyanide		15	5.57	0	19	0	9	0	28	0	29	0	233	52	0	56
8	434	44	33	120	Carbon bisulphide rubber jelly		3 gals.	2.79	12	22	0	9	12	31	13	32	36	93	77	16	40
9a	199	26	4	All	Orthodichlorbenzene jelly		2 gals.	5.17	0	0	0	0	0	0	0	0	0	0	30	0	0
9b	214	43	6	„	Cyanomag dust		4 lbs.	5.97	1	0	0	0	1	0	2	0	17	0	49	2	0
10a	180	7	2	„	Trichlorethylene rubber jelly		3 gals.	4.37	0	0	0	0	0	0	0	0	0	0	9	0	0
10b	151	38	0	„	Paradichlorbenzene cryst. fumigant		14 lbs.	4.37	0	0	0	0	0	0	0	0	0	0	38	0	0
11	325	47	0	—	No treatment		—	—	0	0	0	3	—	—	—	—	—	—	—	—	—
12	585	85	50	All	Castor Seed Meal		7 cwts.	7.96	8	8	2	23	10	31	8	25	20	62	135	7	25
14	462	11	17	—	Control		—	—	17	6	0	4	17	10	18	11	100	59	28	61	36

Old = trees previously recorded as infested now reattacked.

New = trees attacked only since date of treatment.

TABLE II

Summary

No.	Total Number of Trees	Number of Supplies	No. of Trees Treated	Nature of Treatment	Active White Ant cases on 1st August	Average cost per acre	Total cases occurring in 10 weeks		New and Reattacks			
									per 100 diseased trees		per 100 infested tree spaces	
							Old	New	Old	New	Old	New
1	578	153	All	Digging Timber	65	$14.25	33	65	50	100	15	30
2	404	72	Affected	Explosives	29	0.35	14	26	49	91	14	26
3	1789	246	All	Fumigants	97	1.75	25	92	26	93	7	27
4	585	85	All	Castor Seed Meal	50	1.25	10	31	20	62	7	25
5	1106	166	All	Dusts	151	3.10	20	39	13	26	6	12
6	462	11		Control	17		17	10	100	59	61	36
7	1355	202	All	Fumigants, Cyanides, Benzenes and Ethylenes	64	2.00	13	61	20	96	5	23

APPENDIX I

Control of Termites in Young Rubber Trees using Insecticide Dusts

In view of the promising results obtained in these experiments the following method of control of termites by using insecticide dusts is tentatively suggested for use on estates by managers who are willing to assist us in obtaining further experimental data.

1. Infested zones should be demarcated as indicated in the diagram showing (a) supplies (b) infested trees cut out and (c) present infested trees. The zone should include one ring of apparently healthy trees around the infested trees. See diagram attached.

2. The roots should be opened up as shown to a depth of 9 inches or more, if white ants are observed to be entering the tap root at a lower level. The exposed bole of the tree should be cleaned thoroughly and a light dusting of insecticide powder blown on to the bark. All mud walls or debris should be removed from the trunk above ground and more powder blown into the mass of mud and termites so collected and also lightly dusted on the cleaned trunk up to the height reached by the termites. About ¼ to ½ oz. of dust is sufficient for one tree.

3. The crater at the base of the tree is left open for 4 to 5 weeks when a further treatment with insecticide dust is given after which the crater may be filled in.

4. An attempt should be made to trace up termite galleries to find and destroy nests.

5. In view of the fact that termites can destroy a four year old tree within four or five weeks of original attack, it is recommended that a small gang of labourers should patrol infested fields, so as to execute one round of treatment in that period of time, otherwise trees are too far damaged to respond to treatment and eventually have to be dug out.

In heavily attacked fields having a peaty or alluvial soil it is advantageous to treat all trees in the area at the first round of treatment.

6. Suitable insecticide powders are as follows:—

Sodium silicofluoride.
Calcium arsenate.
Cyanomag dust.
Paris Green (plus an equal weight of lime, if used in wet peaty soils).

Imperial Chemical Industries Malaya Ltd. also stock a proprietary Silicofluoride under the name of *Dutox* which can be used.

7. Suitable hand dust guns may be purchased from the Federated Engineering Company, Kuala Lumpur. Rubber bulb dusters may be obtained from Tan Kah Kee & Co., Ltd. Rubber Manufactory, Singapore. In regard to the latter type of duster a short tapered bamboo tube inserted into the neck and protruding 2 inches into the bulb lends rigidity to the nozzle and prevents choking up when dusting in a downward direction.

Suggested method of controlling the termite pest of young rubber trees by the use of fumigants

Infested zones should be demarcated as indicated in the treatment with insecticide dusts.

The tap roots of all infested trees should be opened up to a depth of 9 inches and the tree thoroughly cleaned of mud. Four pieces of impregnated rubber jelly the size of a walnut are then placed round the bole at a depth of about 6 inches below the surface. The hole should be filled in with soil, so that the level of soil slopes away from the tree, as the fumes penetrate better through dry than through wet soil.

In the case of supplies and non infested trees within the zone, three or four similar pieces of impregnated rubber jelly, should be dibbled in to a depth of six inches close around each tap root but not in contact with it.

Termite galleries should be traced to find and destroy nests.

All known infested areas should be inspected once per month and fresh treatment given where necessary.

The following fumigant liquids are suitable for use in this way:—

Orthodichlorbenzene
Trichlorethylene.
Mixtures of the above and
Carbon bisulphide.

The rubber jelly is made by treating small pieces of *dry* rubber clippings or scrap rubber with the fumigant liquids in the proportion of one point of fluid to one pound of dry rubber. More or less liquid may be added according to the required viscosity of the jelly. The jelly should be kept in well stoppered vessels. It is advisable to keep records of treated trees reattacked after four and eight weeks or more and costs of materials and labour used.

The following data would be of great value in our investigations and the writer would be grateful if estate managers would forward to him such information when available.

(1) Area of plot.
(2) Type of soil.
(3) Lie of land.
(4) Insecticide used.
(5) Number of trees in treated zones.
(6) Number of recent supplies.
(7) Number of trees infested with termites.
(8) Labour costs.
(9) Amount of insecticide used.

Inspection after 4 weeks

(10) Number of old cases reattacked.
(11) Number of new cases in or outside zone.
(12) Number of trees retreated.

Inspection after 8 weeks

(13) Number of old cases reattacked.
(14) Number of new cases in or outside treated zones.

Further inspections and retreatment may be carried out if necessary.

APPENDIX II

Control of the termite pest of Young Rubber Trees

Results obtained in routine work on the Experiment Station

In his Report of Insect Pests in Ceylon during 1929 F. P. Jepson of the Department of Agriculture, Ceylon, suggested a method of using Paris Green in control of the termite pest on tea estates. After a little experimentation the method has been adapted to rubber and used to some extent on the Experiment Station. Perchloride of Mercury was also used on a similar number of trees for purposes of comparison.

The method of treatment was similar to that recommended to estates viz. the soil round infested trees was removed to a depth of nine inches, the trees scraped clean of mud and latex and Paris Green powder blown on to the roots and infested parts of the tree. The various fields were inspected periodically, usually at intervals of four to six months, and attacked trees duly treated. Observation however soon showed that it was possible for termites completely to kill a tree within four weeks of the commencement of attack, so that frequently trees were not discovered until they were too far damaged to respond to treatment; the results summarised below under the heading "One treatment" are therefore somewhat disappointing.

Treatment with perchloride of mercury consisted of opening up the roots in a similar way, then spraying the trunk, roots and soil with one pint of a 2 per cent. solution of the chemical or preferably 2 pints of a 1 per cent. solution of the perchloride in water.

During 1932 the following results were obtained:—

Degree of Control

(1) Paris Green.

(a) After one treatment 25 per cent: deaths nil.
(b) After two treatments 70 „ „ : deaths nil.
(c) After three treatments 75 „ „ : deaths nil.

(2) Perchloride of Mercury.

(a) After one treatment 32 per cent: deaths nil.
(b) After two treatments 55 „ „ : deaths 22 per cent.
(c) After three treatments 58 „ „ : deaths 30 „ „

The large death rate during 1932 is due chiefly to the activity of root disease fungi (Fomes) in conjunction with the white ants. In many cases the trees were too far gone with both disease and termite attack and should have been dug out at once.

During 1933 Paris Green only was used until the end of September when for experimental purposes a change was made to Cyanomag.

Degree of control with Paris Green Jan.—Sept., 1933.

(a) After one treatment 42 per cent: deaths 5 per cent.
(b) After two treatments 63 „ „ : deaths 25 „ „
(c) After three treatments 66 „ „ : deaths 32 „ „

Omitting those trees which were obviously too bad to respond to treatment it is found that the degree of control is as follows:—

(a) After one treatment 50 per cent: deaths 2 per cent.
(b) After two treatments 75 „ „ : deaths 13 „ „
(c) After three treatments 78 „ „ : deaths 20 „ „

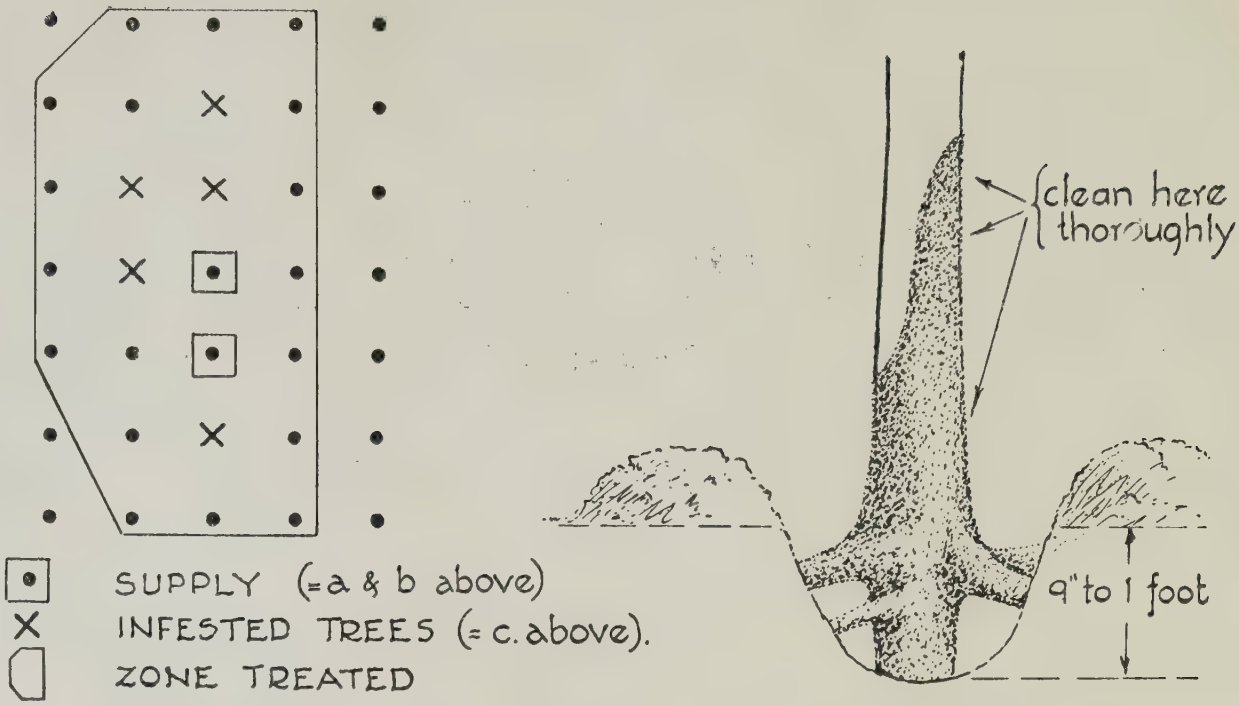
Reference to the root disease records also shows that several trees were given up as lost by attack of root disease fungi before the white ants began to attack them. If these trees are also omitted from the total it is found that the degree of control after three treatments with Paris Green becomes 84 per cent and deaths 14 per cent.

This indicates that Paris Green has given excellent results under ordinary routine estate conditions. With regular monthly rounds of inspection it is almost certain that much better results would have been obtained.

It should be noted that 25 per cent of the trees attacked by white ants had been for some time previously suffering from Fomes root disease. While admitting that attack by root disease fungi predisposes to attack by termites, observations show that the species *Coptotermes curvignathus* will attack well grown, healthy trees of four or five years of age.

Two labourers have now been trained in the work of white ant control to inspect every tree on the Experiment Station once per month, at the same time treating all infected trees and a ring of healthy trees around each diseased one. These trees will be opened up and dusted with insecticide powder. During the year it is hoped that trials with several other insecticide powders will be carried out.

DIAGRAM ILLUSTRATING TREATMENT



THE CAUSES OF DISCOLOURATION IN PRESERVED LATEX

BY

EDGAR RHODES AND K. C. SEKAR

Introduction

In recent years numerous processes have been developed for the application of latex to new manufactures. In many of these processes, the production of a satisfactory article is very largely dependent upon the colour of the preserved latex available; preserved latex of which the colour at the time of delivery to the user, is other than a good white, presents very serious difficulty in processing, and often yields an unsatisfactory product. The number of processes in which a good white latex is a matter of vital importance is increasing rapidly, and it is therefore not surprising that buyers have very rapidly become more discriminating in their choice of sources of supply, and more exacting in their requirements. So much importance is now attached to the characteristic of colour, that those suppliers who have been fortunate in establishing a reputation in European and American markets for the production of a latex which reaches destination in a good white condition, have earned for themselves an assured market, while many of those whose products were not until recently made the subject of complaint, have either lost or are in some danger of losing their markets. Estates wishing to enter the latex market have been called upon by buyers to ship trial consignments as a preliminary to the making of contracts and, in some of these cases, contracts have not been obtained, chiefly because the sample consignments of latex were of unsatisfactory colour on arrival at destination.

The nature of the buyer's complaint is that the latex on arrival at destination, often contains a considerable amount of a blue-grey sludge and that, apart from the presence of this undesirable material, the body of the latex retains a grey or blue-grey colour even after gravitational separation of the sludge. It is very frequently the case that when complaints are made against colour, one or other of certain complaints such as low stability, presence of an undue amount of coagulated rubber, and putrefactive odour, are also associated as rider objections. Complaints of this nature have occasioned some surprise to producers whose latex is undoubtedly of good colour at the time of packing in Malaya, but there is no gainsaying the fact that some latices do develop a very undesirable colour even in the comparatively short period of storage which is represented by the time taken for transport between Malaya and destination.

It has been shown by De Vries and collaborators, (1) and (2), that when latex is treated with ammonia, a precipitate is produced which contains insoluble phosphates together with a certain amount of rubber; that the precipitate is at first slightly yellow and that on long standing the precipitate tends to darken, when iron and hydrogen sulphide become detectable in it. The presence of iron in the deposit found in latex shipped in kerosene tins, has also been recorded, (3), but in the published literature there appears to be no reference to the discolouration which may take place in the body of the latex or to the causes of such discolouration. In view of the importance which now attaches to this characteristic, and in view of the fact that, unless users can obtain supplies of good white latex, present and future developments in the latex industry may be seriously hampered, it was considered desirable to attempt to discover the factors responsible for the development of the defect and to indicate if possible suitable measures against it.

Experimental

(a) Experiments made with the object of determining the role, if any, of latex enzymes in discolouration

Various authors have noted the presence in latex of oxidising enzymes which cause the darkening of a coagulum through the colour stages of pink, and violet, to blue-black and it is a common estate practice to inhibit the action of these enzymes by the addition of sodium bisulphite to latex in the preparation of pale crepe. Eaton (4) and Morgan (5) have observed that by the addition of certain common phenolic bodies to a latex not normally prone to give a discoloured coagulum, a dark coloured rubber is obtained and De Jong (6) indicated that the addition of tyrosine to certain latices apparently containing the enzyme tyrosinase, resulted in a rubber of dark colour. De Vries (7) has noted the fact that during and after the wintering period, the tendency of latex to give a discoloured rubber, is more pronounced. Certain large buyers of latex have recently expressed the opinion that the tendency towards discolouration in the latex from various shipments throughout a year, appears to be to some extent seasonal. These facts taken together suggested the possibility that the tendency of preserved latex as distinct from rubber itself, to discolouration, might also be an enzymic phenomenon and a number of experiments were made to test this point.

(i) *Addition of accessory substances to preserved latex*

Good white latex, collected under normal estate conditions but preserved in glass vessels was treated with small amounts of a range of phenolic substances and stored for three weeks in order to discover whether the discolouration phenomena could be imitated and if

so by what type of accessory body. The substances employed were hydroquinone, orcin, resorcin, quinone, anthraquinone, β napthol α naphthol, phloroglucinol, metol, pyrogallol, amydol, tannic acid and gallic acid. With most of these materials a discolouration of the latex was obtained but this was either :—

(a) A surface oxidation in which the shade of colour obtained, was not the same as is observed in a naturally discoloured latex, and in which there was a gradient of colour intensity from the surface of the latex downwards, the lower layers being lightest in colour; in a naturally discoloured latex, the surface cream layers are almost always pure white in colour.

or (b) A* uniform colour throughout the body of the latex, but of a shade different from that observed in a naturally discoloured latex.

It was concluded from these experiments that the simple addition of phenolic bodies to preserved latex does not reproduce the normal latex discolouration, by action as accessory substances to the enzymes normally present. In experiments described later in this paper, tyrosine was also added to latex as a specific accessory body for the enzyme tyrosinase, but the colour obtained was again of incorrect shade.

(ii) *Addition of enzyme activators and inhibitors*

Samples of latex collected and bulked under normal estate conditions and then preserved in glass vessels, were obtained from an estate whose latex shipments had been made the subject of complaint. When taken for experiment, the latex was of good colour. Ash analysis revealed the presence of an abnormal quantity of iron, but no importance was at the time attached to this fact. From this latex a series of tubes was set up for observation after the addition of traces of the various substances which follow :—

Substances unlikely to assist enzyme activity and which might retard it	Substances likely to assist enzymic activity when added in traces
Sodium hypochlorite	Ferric chloride
Bleaching powder	Ferrous sulphate
Alcohol	Hydrogen peroxide
Sodium bisulphite	Sodium peroxide
	Ammonium persulphate
	Calcium chloride
	Manganese chloride
	Potassium cyanide
	Tyrosine

From these experiments, which were repeated *in toto* on samples drawn from the bulked latex from each of a number of different days' crops, certain general conclusions became possible during an observation period of three weeks.

(i) The control latex assumed slight discolouration.

(ii) The substances added for the purpose of retarding enzyme activity did not yield a latex showing observable differences from the control latex.

(iii) The tubes containing salts of iron, invariably showed an increase in discolouration over control and the type of discolouration was typical of that encountered in commercial latex.

(iv) Traces of hydrogen peroxide, potassium cyanide, sodium peroxide, and ammonium persulphate produced no increase in discolouration and the tendency was rather to reduce it.

(v) Calcium and manganese chlorides produced no observable effect on colour.

Of these conclusions the third and fourth were by far the most striking and prompted further experiments.

Working with similar samples drawn from bulked latex from the same source, several series of tubes were set up against controls. These were arranged

(a) To test the effects of iron salts, hydrogen peroxide and potassium cyanide when applied singly. Hydrogen peroxide and potassium cyanide were added in various amounts ranging from traces, to amounts at which they would be expected to function as enzyme paralysers rather than as activators.

(b) To test the combined effects of iron salts and hydrogen peroxide and potassium cyanide. The peroxide and cyanide were applied at various concentrations as under (a).

Observations were made over a period of two weeks and it became apparent that

(i) Iron salts when applied alone, produced an increase in discolouration over the controls, which themselves showed noticeable discolouration.

(ii) Hydrogen peroxide and potassium cyanide applied alone, showed in no case an increase of discolouration; with increase in concentration of added reagent, the colour was progressively whiter than the control and at the higher concentrations the colour was a good white.

(iii) Hydrogen peroxide and potassium cyanide, when applied together with iron salts, in no case increased the tendency of the iron salts to produce discolouration, but tended to prevent it. At the higher concentrations of peroxide and cyanide, the degree of discolouration of the latex was less than was obtained with iron

salts alone, and was in most cases of the same order as that in the control latex.

The general indications at this stage were that, if the discolouration phenomenon were enzymic, the action must be fairly specifically activated by iron salts, since calcium and manganese salts were ineffective. Hydrogen peroxide, which would be expected to assist an enzymic oxidation process and increase discolouration, when applied in traces to latex, whether activated with iron or not, actually had the reverse effect. In view of the inconclusiveness of the evidence, further information was sought in an approach from a somewhat different angle.

In one method of estimation of tyrosinase activity, the dark coloured substance (melanin) formed, is oxidized by potassium permanganate to a colourless body and, if the discolouration of latex were due to an enzyme activity allied to that of tryosinase, then it should be possible to discharge the blue-grey colour of an *already discoloured latex,* by the action of oxidizing agents. Samples of badly discoloured latex which had been returned by an American buyer, were treated with potassium permanganate and the blue-grey colour was discharged; at the same time however brown manganese salts were precipitated. When treated as an alternative with 1 per cent. by volume of hydrogen peroxide (20 volumes) the colour was discharged immediately to a good white with a slight golden tinge. On standing for 24 hours, a brown precipitate settled out leaving a good white supernatant latex, (see Plate 2). Sodium peroxide and ammonium persulphate behaved similarly, though excess of the latter reagent tended to cause clotting. These observations, although quite indirect, could not be disregarded, since they did not detract from the circumstantial evidence for an enzymic interpretation of the problem. It was obviously desirable to obtain, if possible, evidence which would be more direct by making comparative discolouration experiments on latices of vigorous and less vigorous enzyme activities collected and preserved under standardised conditions.

By the courtesy of the manager of an estate in Selangor it was possible to obtain samples of latex which were ideal for the purpose. In a small area of mixed clones on this estate, certain members yield a latex which is of very vigorous oxidising enzyme activity, others a latex of lesser activity, and others a latex of practically no activity, as judged by the rapidity with which a coagulum obtained by alcohol coagulation, discolours through the stages of pink and violet to a final black; coagula from the more active samples begin to discolour within a few minutes of coagulation while those from the least active latex retain a good colour even after twenty four hours. It was possible therefore to collect latex of very different enzymic activity from trees on the same soil site, and growing within a few yards of each other. Latex was collected separately from

twelve selected trees, ammoniated in each case at the tree, and preserved in closed glass vessels, so that possible adventitious contamination was reduced to the practicable minimum. The enzymic activity of each latex was tested by alcohol coagulation on a small sample, with subsequent observation of the rapidity of appearance of discolouration on the coagulum. By this means the latices were divided into two widely different groups, one of which showed very vigorous enzyme activity and the other of which showed virtually no activity. Within two hours of collection, seven series of twelve tubes were set up. Each series contained a sample from each of the twelve selected latices. The various series covered the following treatments :—

(1) Preserved latex. Control.
(2) „ „ with a trace of added ferric chloride.
(3) „ „ with excess of added tyrosine.
(4) „ „ with traces of added ferric chloride and tyrosine.
(5) „ „ with a trace of added calcium chloride and excess tyrosine.
(6) „ „ with a trace of hydrogen peroxide.
(7) „ „ with excess of hydrogen peroxide.

The seven series of tubes were set aside for six weeks to give ample time for discolouration and at the end of this time the following observations became possible :—

(i) The twelve control tubes covering the simple preserved latex from enzymically active and inactive trees, were all of uniformly good white colour; no observable discolouration had occurred in any tube.

(ii) Every tube in both of the series containing added iron, showed some discolouration and the type of discolouration was typical of that shown by commercial latex.

(iii) In the two series containing excess of free tyrosine, a discolouration was observed but this was in no way similar to that found in commercial latex.

(iv) The two series treated with hydrogen peroxide exhibited uniformly good white latices identical with the controls.

(v) When, in the two series in which a true discolouration had been induced by the addition of ferric chloride, marks were given for colour intensity in each tube, the total number of marks awarded to the members of the active group was greater than that awarded to the inactive group. The marks awarded to individual members, could not however be correlated with their observed initial enzyme activities since three of the six members of the inactive group were each awarded as many marks as the lowest marked member of the active group, and two of the six members of the active group obtained no more marks than the highest marked member

of the inactive group. The addition of iron salts did not therefore in its induction of discolouration, reproduce the well marked differences which existed between the enzymic activity of each member of the active group compared with that of each member of the inactive group.

From this experiment the conclusion seemed inescapable that discolouration is not a simple function of enzyme activity; no control tube showed any discolouration and, since the controls included members which were already very active and therefore in no need of activation, these latices should clearly have been expected to show discolouration. The irregularity of the induction of colour by added iron salts produced no convincing evidence in favour of an enzymic explanation.

Before proceeding with further tests on enzymically active and inactive latices, experiments were made with commercial preserved latex stored in glass and in iron vessels, in order to discover whether the effect of iron salts added in solution, could be reproduced merely by contact with metallic iron. Excessive discolouration was repeatedly obtained in latex stored in iron tubes, when compared with controls stored in glass. Similarly by introducing a strip of drum metal into a glass tube containing latex, excessive discolouration over control, was usually observed after an interval of two to three weeks. Commercial latices from various sources showed however divergent rates of response to iron whether added as salts of iron or as the metal; some responded rapidly and showed appreciable discolouration in less than a week, while others reacted very slowly and showed but slight discolouration after a month's storage in contact with iron. No explanation of this fact presented itself at the time.

At this stage a further set of latex samples was obtained from the same twelve enzymically active and inactive trees mentioned earlier, and experiments were made to test whether or not discolouration was possible in the absence or in presence of metallic iron after having destroyed the enzymes by heat. Where heat treatment was applied, a test tube containing the ammoniated latex was immersed in an oil bath heated to a temperature of 180°C., so that the temperature of the latex should rise quickly to 85-90°C. The temperature of the latex was maintained in this zone for 15 minutes. At intervals a little ammonia was added to guard against coagulation. Four complete series of twelve tubes were prepared as under for observation :—

(1) Preserved latex. Control. Unheated. No iron.

(2) „ „ Control. Heated. No iron.

(3) „ „ Unheated, with a strip of drum metal in each tube.

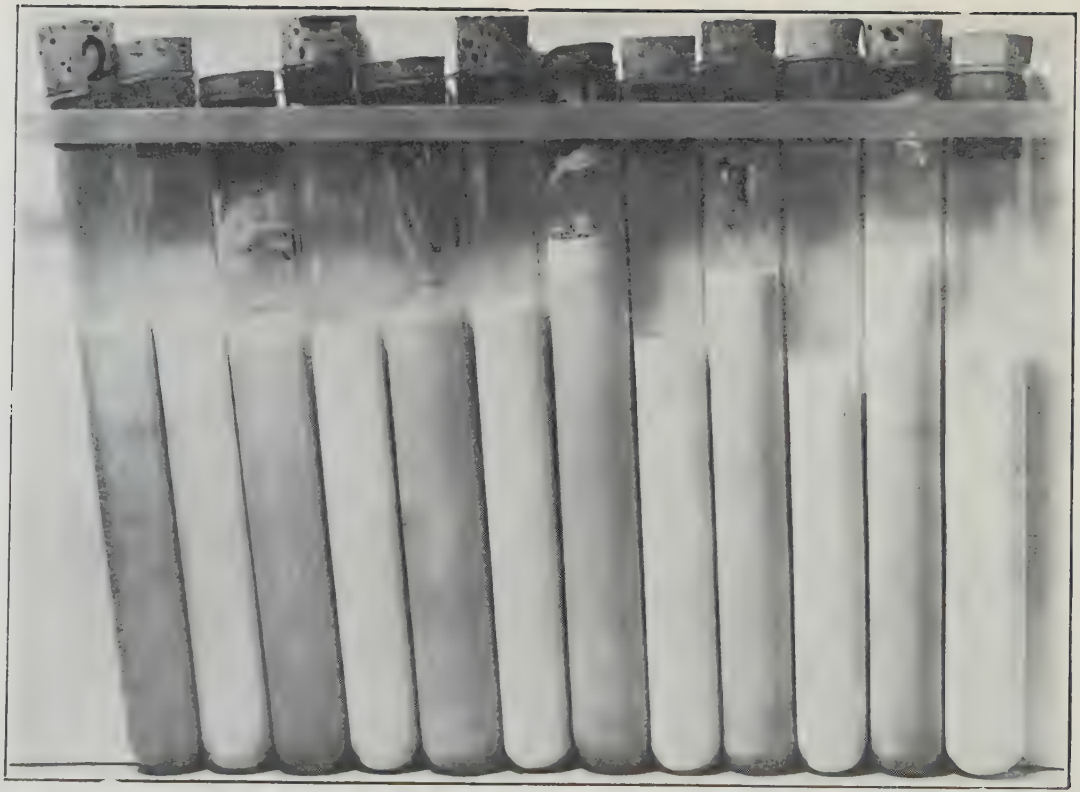


PLATE 1

The induction of discolouration by iron
For explanation, see text

(4) Preserved latex. Heated and containing a strip of drum metal in each tube, the metal having been introduced after cooling the latex.

On these four series of tubes the following observations were made :—

(a) The two complete series of control tubes of unheated and heated latex still retained a good white colour after six weeks' storage. This confirmed the observation made in the previous similar experiment.

(b) Each member of the two complete series of tubes heated and unheated, but kept in presence of metallic iron, showed serious discolouration. The intensity of colour in the series of unheated tubes could not be correlated with enzymic activity.

(c) Of the two series of tubes containing iron, each member of the heated series *discoloured much more rapidly* than the corresponding unheated tube.

Plate 1 shows six pairs of tubes from this experiment which are typical of the differences exhibited by unheated control tubes after six weeks' storage and the corresponding tubes of unheated latex containing metallic iron. On the extreme left of the plate is a tube containing iron; its immediate neighbour is its own control without iron. Each succeeding pair represents a different latex. The pair on the extreme left and the pair on the extreme right are from enzymically inactive latices and the remaining four pairs are from enzymically active latices.

The fact that, after a heat treatment sufficient to destroy the enzymes, the rate of response to iron was actually increased, disposed finally of the possibility that discolouration might be due to enzyme activity. The exploration made, in testing this point, had however provided clear evidence that one of the causative factors is the presence of iron and that the effect of heat on latex is to increase its rate of response to discolouration by iron. A means of restoring a good colour to an already discoloured latex had also been found in the use of hydrogen peroxide and other oxidising agents and there was strong preliminary evidence that these bodies, when added to a latex of good colour, would delay the induction of discolouration by iron. Evidence was still required which would indicate the nature of the factor or factors complementary to iron and which with it result in discolouration.

(b) Experiments with potassium cyanide and hydrogen peroxide as preventives of discolouraton

The effect of potassium cyanide, in the earlier experiments with good white latex, had been similar to that of hydrogen peroxide in retarding the onset of discolouration, and it was now found that, like

hydrogen peroxide, it was able to restore a good colour to an already badly discoloured latex (See Plate 2). Its effect was not however instantaneous as in the case of hydrogen peroxide, but an amount of potassium cyanide equal to 0.075 per cent. of the weight of latex restored a good colour in a few minutes. Storage experiments, with discolouration-susceptible latex in sealed kerosene tins, indicated that a smaller amount, equal to 0.025 per cent. of potassium cyanide by weight, was sufficient to suspend the onset of discolouration for three weeks during which period an appreciable colour had developed in the control latex; in storage periods of two months however, an appreciable discolouration did develop in cyanide treated latex, but the colour was less marked than in the controls. In similar storage experiments with 1 per cent. by volume of hydrogen peroxide (20 volumes) similar results were obtained. Storage in presence of 0.075 per cent. potassium cyanide was effective for approximately five weeks but appreciable discolouration had developed in ten weeks; the discolouration was however less severe than in controls of the same latex.

In all cases in which discolouration had occurred on storage, either in the absence of hydrogen peroxide and potassium cyanide, or, after very long storage in their presence, a further treatment with either reagent restored a good colour.

In numerous experiments, where discolouration had been induced by the addition of soluble iron salts, or by the introduction of drum metal, the two reagents were invariably effective in discharging the colour.

(c) Experiments to discover the factor or factors complementary to iron

Samples of the sludge, which is always found in naturally discoloured latices, were always found to yield hydrogen sulphide on treatment with mineral acid and the acidification was sufficient to discharge their dark colour. Iron was invariably present in the sludge, and the indication therefore was, that, in so far as concerned the colour of the sludge, as distinct from the discolouration which may be present throughout the body of the latex, the dark colour present is due to the formation of sulphides of iron and the factor complementary to iron would therefore be sulphur bodies.

It was at first considered somewhat unlikely that the discolouration which occurs in the body of the latex and which persists even through long settling periods, could also be attributed to sulphide formation, but experiments were made with fresh latex in order to discover whether, under conditions specially favourable to the formation of sulphides, discolouration as well as sludge deposition would be encouraged.

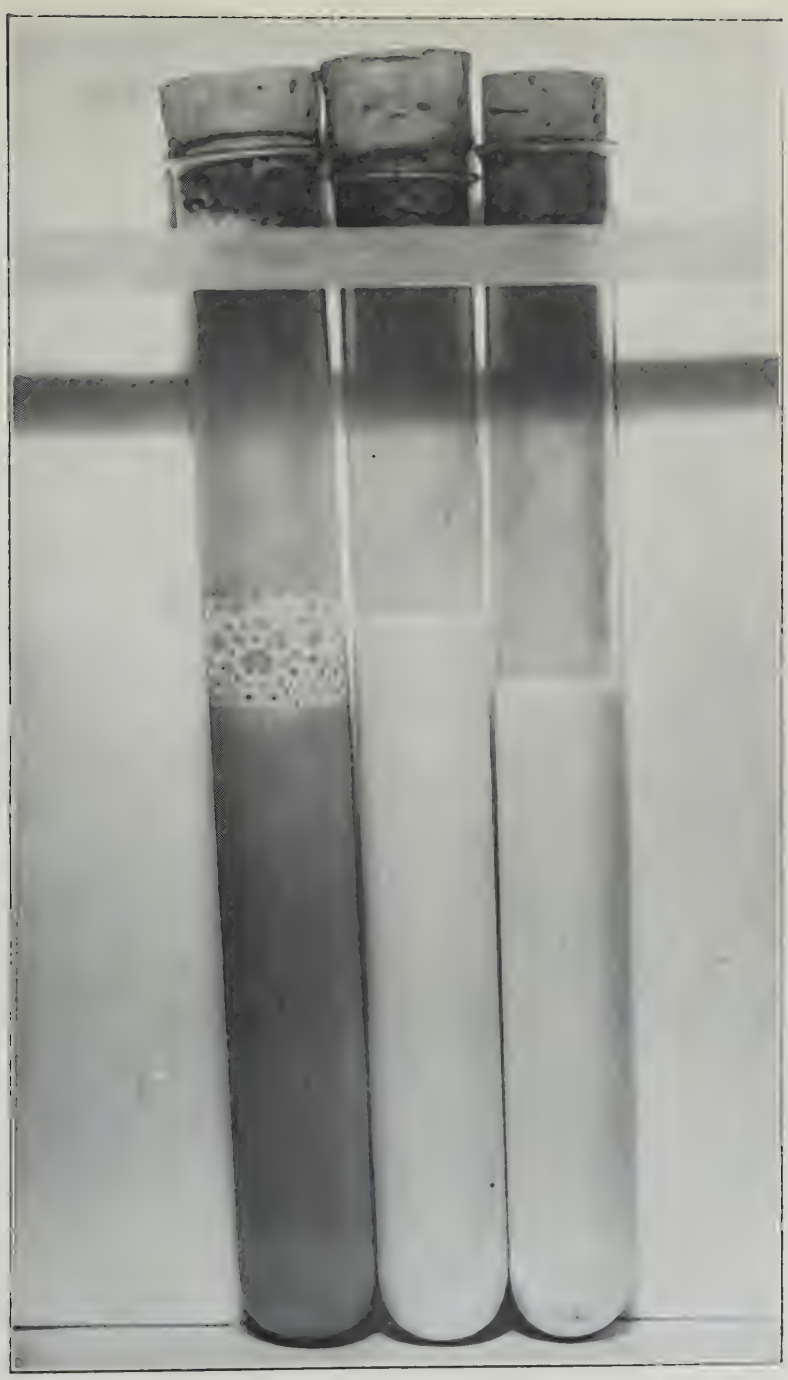


PLATE 2

Restoration of good colour to a discoloured latex

Left to right :—Discoloured latex, the effect of hydrogen peroxide, and the effect of potassium cyanide

(i) *Experiments on latex partially putrefied in absence of iron*

Very fresh latex was obtained at the Institute at 9.30 a.m. and, after ammoniation of a control sample, the remainder was placed in a glass vessel and three further samples were drawn from it for ammoniation at intervals of approximately two hours, in order to follow progressively the effects of natural putrefaction; as bacterial putrefaction proceeds, hydrogen sulphide is produced and after ammoniation the readiness of the latex to produce sulphides in presence of iron, should be increased. As each sample was ammoniated, a strip of drum metal was inserted into the tube and the whole series was left for one month for observation. At the end of this time it became clear that latex which had been allowed to approach the stage of clotting in the absence of iron, before ammoniation and subsequent storage in presence of iron, showed appreciable discolouration and appreciable precipitation of dark coloured solids, while control latex, also stored in presence of iron, but ammoniated while very fresh, was yet in a good white condition. The observations indicated also that the discolouration in the body of the latex and the deposition of the dark coloured deposit proceeded simultaneously; in no case was a dark coloured deposit observed beneath a good white supernatant latex; rather was discolouration visible in the body of the latex as soon as, or before appreciable deposition of solids became apparent. Repetition of the whole experiment, confirmed these observations.

Commercial preserved latex which had been drawn from an estate bulk and stored in a glass vessel for a week before being taken for experiment, was placed in a tube with a strip of drum metal; a further sample of the same latex was partially de-ammoniated and set aside in air until putrefaction commenced, when it was re-ammoniated and again placed in a tube with a strip of drum metal. The partially putrefied re-ammoniated sample, discoloured most severely. Discolouration of the latex and deposition of dark solids proceeded simultaneously.

Fresh latex was placed in a collodion sac in a vessel of distilled water, and allowed to remain for seventeen hours during which time spontaneous coagulation proceeded within the sac. The clear unconcentrated dialysate from this latex, when ammoniated and treated with a trace of ferric chloride, gave a distinct blue-black colour in two hours, but no deposit was obtained.

The inference was drawn that deposition of dark sludge and discolouration in the body of the latex, were in some way connected.

(ii) *Experiments on latex partially putrefied in presence of iron*

In the previous putrefaction experiments the latex was not allowed to come into contact with iron, until the acids developed during

putrefaction, had been neutralized with ammonia. It was now sought to test the effect of putrefaction in presence of iron before ammoniation; in these experiments the acids developed, which would consist in the main of lactic acid, were therefore allowed to attack the iron before ammoniation, so that sulphur bodies and soluble iron would both be available in the latex at the moment of ammoniation.

The latex taken for these experiments was chosen not for its reactivity to iron, but for its peculiar resistance; normal preserved latex from this source, when in contact with iron for periods up to three months, shows little sign of discolouration or sludge deposition. Fresh latex, placed in a shallow dish containing strips of drum metal and allowed to putrefy, showed a blue discolouration in thin surface films immediately above the metal strips after four hours, that is when putrefaction, as judged by odour, was well advanced. Ammoniation at this stage gave an immediate blue-black discolouration, but deposition of solids was not apparent for some hours. The ammonia treated latex was placed in a tube with a strip of drum metal and, in three days, developed an extremely bad discolouration and a heavy deposition of solids. Hydrogen peroxide and potassium cyanide discharged the dark colour of the latex and of the deposit.

In a further experiment with latex from the same source, an attempt was made to test progressively the effect of putrefaction in presence of iron, before full ammoniation and storage in presence of iron. A control sample of the latex was fully ammoniated when fresh from the field, and placed in a tube in presence of drum metal. In addition, fresh latex, and samples containing 0.05, 0.10 and 0.20 per cent. ammonia respectively, were exposed in presence of iron for 20 hours. At the end of this period, the fresh latex was badly clotted, putrefactive odours were very pronounced, and surface discolouration was visible. After sieving to remove clots and lump, the latex was ammoniated, when a distinct and typical *discolouration became apparent immediately*. The discoloured ammoniated latex was placed in a tube with drum metal and set aside for observation. The latex to which 0.05 per cent. of ammonia had been added before exposure, had a decided putrefactive odour after 20 hours, but severe clotting, such as had occurred in the fresh latex, was absent. Ammoniation, before storage in presence of drum metal, again revealed an immediate discolouration which was less pronounced than in the case of the exposed fresh latex. The latex containing 0.1 per cent. ammonia, had lost its ammoniacal odour during the exposure period, but putrefactive odours were not pronounced. On ammoniation a very faint discolouration appeared immediately. Where 0.2 per cent. ammonia had been added, the exposure period of 20 hours produced no putrefactive odour. On full ammoniation no immediate discolouration was apparent. The various tubes, now containing 0.5 per cent. ammonia and strips of metal, were kept under observation

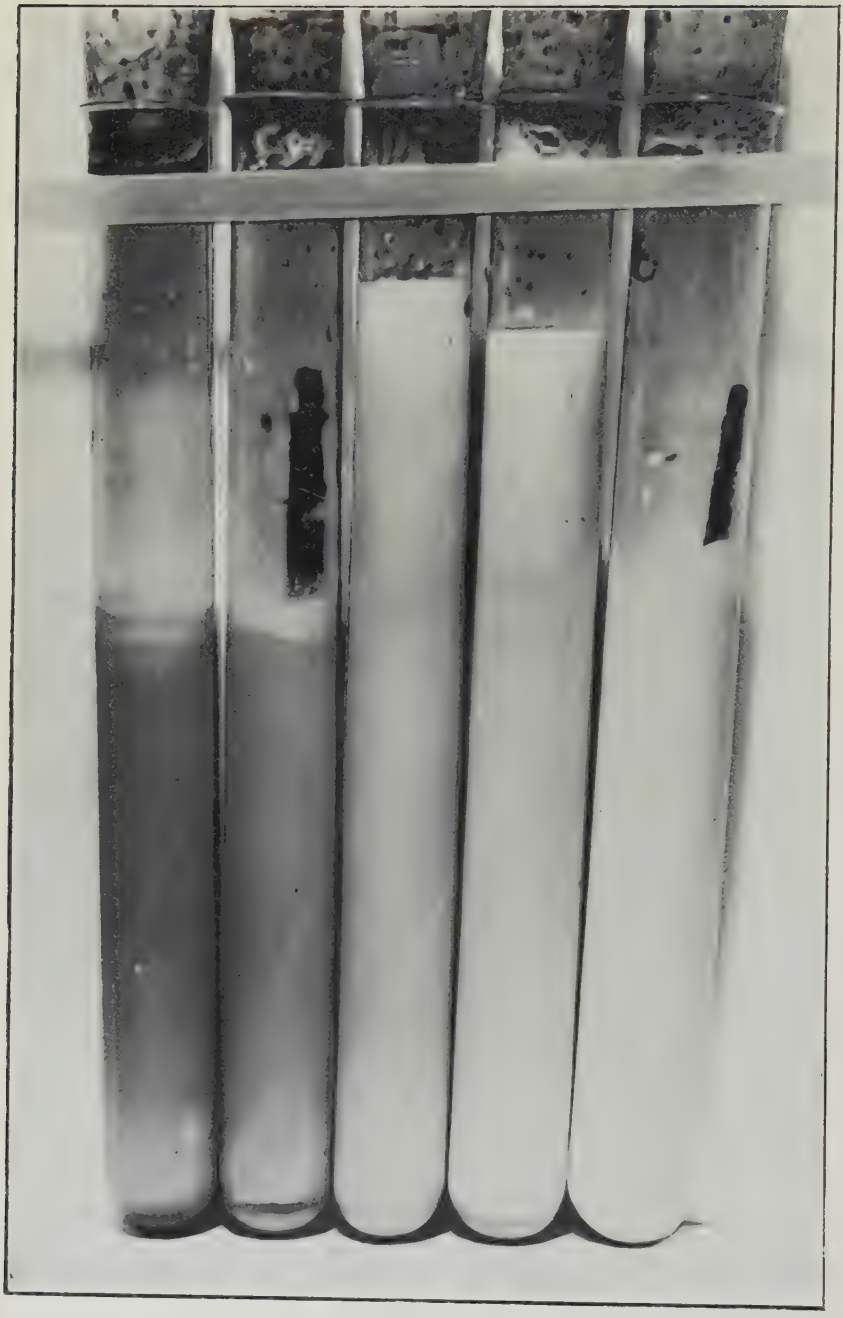


PLATE 3

The effect of partial putrefaction in presence of iron before ammoniation

For explanation see text

for a week and at the end of this time discolouration and dark solid deposits were apparent in every tube save the control; Plate 3 shows the variation in the discolouration. From left to right the tubes are

1. Fresh latex severely putrefied before final ammoniation.
2. Latex containing 0.05 per cent. ammonia at the time of exposure. Putrefaction less severe before final ammoniation.
3. Latex containing 0.1 per cent. ammonia at the time of exposure. Putrefaction before final ammoniation less severe than in 2.
4. Latex containing 0.2 per cent. ammonia at the time of exposure. Putrefaction before ammoniation less severe than in 3.
5. Control latex ammoniated immediately and not exposed for putrefaction.

It is seen from the illustration that, while the control latex retained an exceedingly good colour, putrefaction in presence of iron initiated very serious discolouration.

The experiment also indicated that, even with a latex which is normally very resistant indeed to iron, there are conditions under which discolouration can be produced at the very moment of ammoniation. By causing the latex itself to provide a sufficiency of soluble iron and of hydrogen sulphide before ammoniation, these conditions are realised and discolouration is then apparent before deposition of dark solids commences. The inference was drawn that latex discolouration is probably a preliminary to deposition of solids and that the two manifestations are, in all probability, successive stages of the single process of sulphide formation.

In further experiments, evidence was obtained that, while the effect of heating a freshly preserved latex in presence of iron is generally to increase the rate of discolouration, the effect of heating a latex, which before ammoniation has been subjected to partial putrefaction in presence of iron, is still further to increase the rate of discolouration. In these experiments also, discolouration was a preliminary to deposition of solids and the conviction was thereby strengthened that the appearance of discolouration in latex merely marks the beginning of a sulphide formation in which some, but not all the sulphide is later deposited.

A badly discoloured commercial latex was separated from its heavy sludge and set up for creaming with gum tragacanth. The serum obtained was of a deep blue-black colour; the colour was discharged by hydrochloric acid and the acid solution responded to tests for iron. Further if the discolouration is due essentially to the presence of traces of finely dispersed or colloidal iron sulphide, exposure of the blue-black serum to air should discharge the discolouration in a few hours, and hydrogen peroxide should dispel it instantly. The serum was separated. A portion was exposed to air

and another portion was treated with hydrogen peroxide. In both cases the colour was discharged; in the first case overnight and in the second case instantly.

It remained to demonstrate that discolouration and sludge deposition could be induced in latex by purely artificial means.

(iii) *Artificial discolouration of latex.*

It is well known that, if very dilute solutions of iron salts are treated with ammonium sulphide or with hydrogen sulphide in alkaline solution, the iron sulphide formed is not deposited immediately but yields a greenish-black suspension, from which iron sulphide settles out only on long standing. It is also well known in analytical work that iron salts are exceptionally difficult to precipitate in presence of organic matter in general, and sugars and organic acids, such as lactic acid and tartaric acid, in particular. A latex medium, is therefore one which should tend to retard the precipitation of iron sulphide.

In order to imitate the effect of putrefaction in presence of iron prior to ammoniation, drum metal was exposed to weak solutions of lactic acid which is the chief acid developed in the natural putrefaction of latex. It was found that, if a lactic acid solution of strength 0.02 per cent. were exposed to iron for two hours, subsequently treated with excess ammonia and a little fresh latex, and then treated with a very small amount of hydrogen sulphide, a distinct discolouration developed immediately; the discolouration was still apparent after an observation period of a fortnight, during which some deposition of dark solids occurred. A control, latex—ammonia—water—hydrogen sulphide mixture showed no discolouration at all. With longer exposure of iron to stronger solutions of lactic acid and the passage of a large excess of hydrogen sulphide after ammoniation and addition of latex, the discolouration was less stable, and more pronounced deposition of solids occurred. In all cases, hydrogen peroxide and potassium cyanide discharged the discolouration as they do in a naturally discoloured latex. These experiments imitated very closely the results observed when fresh latex is allowed to stand for some hours in presence of iron before ammoniation, which then brings about immediate discolouration. Taking however the case of a latex which, although not allowed to putrefy appreciably before ammoniation, yet discolours slowly in the course of two or three weeks exposure to iron, it was necessary to show that, by exposure of iron to weak solutions of ammonia, sufficient iron could be brought into solution by alkaline as distinct from acid corrosion, to discolour fresh latex in presence of ammonia and hydrogen sulphide. Strips of drum metal were exposed to an alkaline solution containing 0.6 per cent. ammonia. The attack upon iron was very much slower than in the case of the weak solutions of lactic acid, but after approximately one week, the alkaline solution responded to hydrogen sulphide and

gave a distinct discolouration to added latex. This result again simulated the general experience with commercial latex, in which discolouration usually takes some days to make its appearance. There was now little doubt that the factors iron and sulphur bodies are together responsible for the discolouration of commercial preserved latex.

That in certain cases the degree of discolouration is limited by the available suphur bodies or iron, is instanced by two observations :—

(a) Some naturally discoloured latices, when treated with a little hydrogen sulphide, were found to show an immediate increase in discolouration, indicating the presence of available soluble iron.

(b) Eaton, Grantham and Day, (8), describe the anaerobic coagulation of latex in presence of sugars, by which process an unusually large amount of lactic acid and an unusually small amount of hydrogen sulphide are produced in comparison with a simple spontaneous coagulation. By allowing a sugar treated latex to stand in presence of iron for 4 hours, the amount of iron taken into solution should be greater than in the case of a latex containing no added sugar but the comparatively small amount of hydrogen sulphide produced, would be the limiting factor in discolouration and on ammoniation the sugar treated latex should show less discolouration than the control latex. If however both ammoniated latices were subsequently treated with hydrogen sulphide, the sugar treated latex should then show the greater discolouration by virtue of the greater available amount of dissolved iron. An experiment made to test the point, gave positive results.

It has been observed by De Vries (1) that preserved latex, which has been stored for some time, yields hydrogen sulphide on acidification, whereas this does not occur with fresh latex. The observation indicates that one effect of preservation with ammonia is the gradual production of soluble sulphides, presumably from the sulphur bodies of the proteins present. There is therefore very good ground for the theory that the discolouration of preserved latex and the formation of dark sludge, are both due to the formation of iron sulphide within the body of the latex and the experiments described have led to this conclusion. An interpretation such as this would account for the final fact that a naturally discoloured latex almost invariably has an upper layer of cream which is pure white. Allowance must be made for the fact of a high rubber content of 60 per cent. or over in this zone, with a correspondingly small proportion of the serum medium in which discolouration occurs. It must also be remembered that the surface is the only part of the latex which is exposed to air. In the light of the further experimental fact that a discoloured serum regains a good colour when exposed to air, by oxidation of the sulphide present, the fact of a good white surface cream on an otherwise discoloured latex is in no way unexpected.

Discussion

In the foregoing pages it has been shown that discolouration in preserved latex is governed by two factors

(a) the presence of soluble iron, and

(b) the presence of hydrogen sulphide or other soluble iron-reactant sulphides.

Assuming that at some time between the tapping of the tree and receipt of the preserved latex at destination, the latex has been in contact with iron for an appreciable period, then it becomes possible to account in theory for the two major observations made by buyers namely :—

(1) that one or more of the following faults—presence of coagulum, putrefactive odour, and low stability, are often associated with an unsatisfactory colour in latex.

(2) that at certain seasons of the year, the probability of a shipment reaching destination in a discoloured condition is greater than at other seasons.

With regard to the first observation, it is obvious that, if a latex is collected and allowed to reach the factory in poor condition, with no precautions against incipient putrefaction and coagulation, and if, after crude sieving, it is bulked and ammoniated, not only does it contain traces of dissolved iron and hydrogen sulphide which make for discolouration, but it also contains aggregates of globules caused by incipient coagulation and these make for poor stability. Where the amount of preservative is so inadequate that putrefaction and coagulation occur in the shipment containers, then discolouration again follows naturally upon the development of these favourable conditions. It is therefore only to be expected that discolouration is in many cases accompanied by other undesirable features.

With regard to the second observation, it is common knowledge that, at certain seasons of the year, notably after wintering, latex is unusually prone to premature coagulation which, in the absence of special precautions, pre-supposes an undue tendency toward acid corrosion of collecting vessels and formation of traces of hydrogen sulphide before the latex reaches the stage of ammoniation. The precise differences which occur in the composition of the latex are not fully understood, but it has been assumed that the content of sugars is somewhat higher than normal after wintering, which would in itself imply a somewhat more rapid development of lactic acid and a somewhat greater degree of acid corrosion of iron. It is not therefore surprising that latex shipped under present conditions seems to show seasonal variation in its degree of discolouration.

The degree of natural stability in latices from different sources provides also a possible part explanation of the fact that latex from some estates is generally received at destination in better condition

than that from other estates. It has been observed that, with certain preserved latices, which are peculiarly resistant to discolouration, the tendency towards spontaneous coagulation when in the unpreserved condition is less than average and it is therefore to be supposed that the degree of acid corrosion of vessels between tree and factory is also small. It has been confirmed with one such latex, of which trial shipments have reached America in excellent condition, that the ash of the fresh latex at the time of arrival at the receiving station, contained no qualitatively detectable amount of iron. After ammoniation, if discolouration is to take place in transit, the necessary iron must be brought into solution purely by alkaline corrosion which has been shown to be much slower than acid corrosion; similarly, since little or no putrefaction has taken place before ammoniation, the slow development of soluble sulphide, which appears to take place in preserved latex by the alkaline hydrolysis of protein material, is now the sole source of this essential factor and is not merely an accessory, supplying an additional quota to the amount which might in other circumstances be present before ammoniation. It is further not beyond the bounds of possibility that latex owes its natural stability, at any rate in part, to the resistance of its proteins to decomposition, so that a latex of high natural resistance to spontaneous coagulation, would be less liable to discolouration in transit than one of low resistance. It is very probable that the natural stability factor is important in this connection, though it is clear, from the putrefaction experiments described, that even a very resistant latex can be caused to discolour very rapidly if too much time is allowed for decomposition in presence of iron before ammoniation; thus, under present conditions, an estate of which the latex shipments show a good white colour, may also owe part of its success to the arrangements governing the length of time between collection and final ammoniation, or alternatively to arrangements for very early ammoniation in the field.

It is clear that since every contact of latex with iron, whether the latex be in the fresh or in the preserved condition, carries its dangers, the ideal of production would preclude contact with iron at every stage between tree and buyer; it would either abolish completely every iron vessel whether used for collection, storage or transport or, in the alternative, cause every iron vessel to be so treated on its surface with wax or with some carefully selected variety of paint-like coating, that direct contact of latex with iron, was rendered impossible. Although it is true that the steel drum commonly used for latex shipment is now shown to be unsatisfactory for the purpose, and although the best alternative is bulk shipment from waxed storage tanks to waxed steamer tanks which, by reason of their surface protection and by reason of the smaller ratio of surface area of container to volume of latex, approach very near to the

ideal, much latex must of necessity yet be shipped in the unsatisfactory drum; the wooden barrel presents an obvious advantage over metal drums, in that it contains no iron, and it is not easy to decide whether the reluctance shown up to date by practically all buyers to accept latex so shipped, is not based more on prejudice than on some firmly grounded reasoning against it; containers of stainless steel or other resistant metals must at present be ruled out on account of cost; the brand new kerosene tin, by reason of its tinned coating, possesses a clear advantage, and, although in certain other respects it is perhaps not acceptable to buyers, it yet merits consideration from the point of view of retardation of discolouration; the ready assembled steel drum, whether new or second-hand, having no interior protective coating, is not only unsatisfactory by reason of the absence of such coating, but also by reason of the fact that it is only with extreme difficulty that the estate can apply a protective coating, and even then the coating cannot be guaranteed to be either uniform or continuous. The treatment when attempted, is extremely wasteful of time and material. Since however no new drums, which have been given a satisfactory internal treatment before assembly, are at present on the market, it seems that the present unsatisfactory state of affairs must inevitably continue for some time; many shipments of latex must yet reach destination in a more discoloured condition than would be the case if the really satisfactory and at the same time cheap container which is probably one of the greatest immediate needs of the latex industry had been standardised and had become available.

To the argument that, since no satisfactory container is yet available, it is useless to take precautions at other stages in production, the answer is that it is now shown to be more than ever incumbent upon the producer of latex, to devote very great care indeed to its preparation, since it is now apparent that a great deal of the trouble may have become potentially if not visibly present between tree and factory; possible sources of iron contamination, in this short stage of the history of the latex, are numerous, and include the dirty latex cup. containing iron-bearing soil, the collection pail and/or the larger transport vessel; if semi-clean, bacteria-fouled pails, and other primary transport vessels, which act as accelerators of spontaneous coagulation, are used in the absence of ammonia as an anti-coagulant, the resulting slight acid corrosion may, in conjunction with the later effects due to the container itself, make the difference between a passable latex and a latex showing serious discolouration. It therefore behoves the producer, who is admittedly working at a disadvantage, to take every possible precaution against unclean vessels, careless collection and incipient coagulation between tree and factory. In the field, for a long transport to factory, the advantage of the use of a small quantity of ammonia is obvious. Sodium sulphite solution is not to be recommended for the purpose. Investigation is being made

of the most suitable media for coating, collecting, transport, bulking and storage vessels.

Where estates ship, as a single monthly consignment, the accumulated crop of a whole month, it is at present the exception rather than the rule to find a storage tank sufficiently large to hold the whole bulk; it is usual to find tank space sufficient for only one day's crop. The effect of such a paucity of tank space is that the latex must be filled into the transport drums daily, and the latex in some drums is therefore in contact with iron for almost a whole month before shipment, while other drums of the same consignment contain freshly packed latex. Buyers often report that in a single monthly consignment, great variation of colour occurs between drum and drum. In the light of the present experiments, the explanation is obvious and with it the need for large estate storage tanks which can be adequately coated internally with wax or other suitable medium; storage of the accumulating consignment can by this means be achieved without undue contact with iron and monthly shipments can be expected to show not only uniformity in colour, but also an improved colour. The large storage tank lends itself also to the removal of some undesirable material from the latex before shipment.

The experiments, in their indication that part at any rate of the phenomenon is colloidal, would lead at once to the conclusion that the attempt to re-condition an already badly discoloured latex by centrifugal clarification, would be only partially successful, in that only the coarser precipitable sulphide would be removed. Experiments made at the Institute had already given indications that such was the case and in a private communication from a large American buyer, extensive experiments are described which supply full confirmation that centrifugal treatment is in fact only partially successful. It would be fallacious to argue however, that a centrifugal clarification of freshly preserved undiscoloured latex, aimed at the removal of dirt, rust flakes from containers and other impurities, is not a desirable estate measure.

Until such time as the ideal container becomes available, it will clearly be impossible for the estate to guarantee that a latex, having a good colour at the time of shipment, will also be of good colour on arrival at destination and in the drafting of latex contracts specifying a type of container and at the same time a latex of good colour, considerable caution is therefore advisable.

Estates are warned that the use of hydrogen peroxide and potassium cyanide must not be adopted except at the direct and specific request of the buyer.

Summary

Discolouration in preserved latex is attributed to contamination with iron and to the presence of hydrogen sulphide or soluble iron-reactant sulphides.

Acknowledgements

The authors' thanks are due to Lt. Col. B. J. Eaton for his continued interest in the work and to Mr. R. O. Bishop who, in a recent visit to America, established contact with numerous buyers, and was able to forward to us samples of discoloured latices upon which some of the earlier experiments were carried out.

The various estate managers who supplied latex samples examined in the course of the investigation, and of whom it is felt that some might desire to remain anonymous, will it is hoped accept our thanks.

The photographs reproduced in the paper were taken by Mr. J. D. Hastings to whom acknowledgement is also due.

21st. February, 1934.

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QUEBRACHITOL

A method of preparation of quebrachitol from factory serum, has been described by Rhodes and Wiltshire in this Journal, Vol. 3, No. 3, page 160. In the search for uses for this material, it became possible, with the help of Mr. B. D. Porritt, Director of the Research Association of British Rubber Manufacturers, to supply to Drs. McCance and Lawrence of the Diabetic Clinic, King's College Hospital London, a quantity of quebrachitol prepared at the Rubber Research Institute. These investigators wished to explore its possible use as a sweetening agent for the food of diabetic patients.

The results of their investigation have now been published in the Biochemical Journal Volume XXVII, page 986, 1933. The authors indicate that any sugar substitute for use in cases of diabetes, must satisfy three requirements :—

(1) It must have a pleasant sweet taste and should preferably be sufficiently soluble in water to make a sweet syrup.

(2) It must not be metabolised as a sugar.

(3) It must be free from harmful effects even when taken in large doses.

The authors have found by a series of experiments on human subjects and on rats, that quebrachitol could satisfy the first two requirements; it is very soluble in water, but it is not however so sweet, weight for weight, as cane sugar or glucose. When used in larger amounts, a satisfactory degree of sweetness can be obtained. Quebrachitol is not metabolised as a sugar and does not, as in the case of a sugar, raise the blood-sugar, increase the deposition of glycogen in the liver, or relieve hypoglycaemia.

It was found however that quebrachitol does not satisfy the third requirement, since it produces harmful effects when taken by mouth. When taken in amounts such as would be employed for the purpose of sweetening foods, severe diarrhoea or colic results and on this account quebrachitol cannot be recommended as a sweetening agent.

12th January, 1934.

E. R.

MALAYAN PATENTS RELATING TO RUBBER

PART II

BY

E. Rhodes and J. L. Wiltshire

In the previous number of this Journal, Vol. 5 No. 1. September 1933, a list is given of patents relating to rubber granted in the Federated Malay States and Straits Settlements, including the Registration of U. K. or other British Patents.

A survey has been made of the patents listed in Parts I and II of the foregoing (Patents granted in the Federated Malay States and Registration of U.K. and other British Patents in the Federated Malay States) and those specifications which appeared to be of general importance have been copied and abstracted. The copies were made in Kuala Lumpur by the courtesy of the Commissioner of Trade and Customs S.S. & F.M.S. It was impracticable to make a similar survey of the Straits Settlements' specifications and registrations but, in general, it will be found that there are very few specifications of interest to the planting industry which have been filed in the Straits Settlements and not in the Federated Malay States. The specifications filed only in the S.S. are usually concerned with manufacturing processes and are of more interest to rubber consumers than to rubber producers.

The abstracts of the selected patents are given here under general headings of subject matter. Table I gives the headings of the various classes and the number of the corresponding section. To facilitate reference from the complete list published previously the numbers of the selected patents are given in Table II together with the heading under which each is classified.

TABLE I

Section No	General Heading	Number of patents in the section
I	Chemical pre-treatment of latex ...	13
II	Concentration of latex by centrifugal machines	2
III	Concentration of latex by creaming ...	8
IV	Concentration of latex by evaporation ...	9
V	Concentration of latex by filtration ...	2
VI	Compositions of latex with other materials	14
VII	Impregnation of fibres with latex ...	1
VIII	Electro-deposition of rubber ...	9
IX	Vulcanisation of latex	4
X	Spray-drying of latex	8
XI	Drum-drying of latex	1
XII	Coagulation vessels	3
XIII	Coagulation processes	5
XIV	Machinery for the treatment of rubber ...	3
XV	Vulcanisation of rubber	3
XVI	Rubber roadways materials ...	4
XVII	Preparation of soft rubber	1
XVIII	Production of oil from rubber ...	2
		92

TABLE II

F.M.S. Grant No.	Classification
100	Coagulation vessels
103	Coagulation processes
111	do. do.
188	Spray-drying of latex
194	do. do.
215	Compositions of latex with other substances
216	do. do. do. do.
223	Vulcanisation of rubber
241	Rubber roadways material
247	Vulcanisation of rubber
256	Vulcanisation of latex
261	Rubber roadways material
270	Impregnation of fibres with latex
276	Spray-drying of latex
283	Machinery for the treatment of rubber
334	Compositions of latex with other substances
359	Drum-drying of latex
370	Spray-drying of latex
373	Electro-deposition of rubber
374	do. do.
376	Concentration of latex by evaporation
380	Compositions of latex with other substances
410	Spray-drying of latex
411	Production of oil from rubber
429	Spray-drying of latex
450	Chemical pre-treatment of latex
453	Electro-deposition of rubber
454	Concentration of latex by evaporation
457	do. do.
475	Vulcanisation of latex
498	Chemical pre-treatment of latex
506	Electro-deposition of rubber
507	Spray-drying of latex
519	Compositions of latex with other substances
523	Concentration of latex by creaming
527	Electro-deposition of rubber
529	Compositions of latex with other substances
530	do. do. do. do.
533	Electro-deposition of rubber
536	Concentration of latex by evaporation
537	Chemical pre-treatment of latex

F.M.S. Grant No.	Classification
551	Electro-deposition of rubber
557	Compositions of latex with other substances
558	Rubber roadways material
566	Production of oil from rubber
573	Compositions of latex with other substances
601	Concentration of latex by evaporation
627	Chemical pre-treatment of latex
628	Vulcanisation of rubber
629	Concentration of latex by creaming
652	Chemical pre-treatment of latex
653	do. do. do.
659	Concentration of latex by creaming
663	Chemical pre-treatment of latex
664	Concentration of latex by creaming
665	do. do. do.
677	Chemical pre-treatment of latex
678	do. do. do.
682	Spray-drying of latex
695	Coagulation vessels
698	Vulcanisation of latex
699	Rubber roadways material
703	Chemical pre-treatment of latex
705	Concentration of latex by evaporation
712	Machinery for the treatment of rubber
718	Manufacture of soft rubber
719	Coagulation vessels

British Patent. F.M.S. Registration No.	Classification
4	Concentration of latex by centrifugal machine
7	Coagulation processes
13	Concentration of latex by creaming
47	Electro-deposition of rubber
58	Concentration of latex by creaming
65	Vulcanisation of latex
66	Chemical pre-treatment of latex
67	do. do. do.
68	Coagulation processes
71	Concentration of latex by evaporation
72	Coagulation processes
85	Chemical pre-treatment of latex
95	Concentration of latex by centrifugal machine
102	Concentration of latex by evaporation
103	Compositions of latex with other substances
106	do. do. do. do.
108	do. do. do. do.
125	Concentration of latex by creaming
127	Concentration of latex by evaporation
130	Compositions of latex with other substances
131	do. do. do. do.
139	Concentration of latex by filtration
140	Concentration of latex by evaporation
147	do. do. do.
148	Machinery for the treatment of rubber

Section I

Chemical Pre-treatment of Latex including Preservation

(1) The Naugatuck Chemical Co.
F.M.S. Grant No. 450 (1925)
Improved Manufacture of Rubber containing Mixtures and Articles thereof

A normal alkaline base salt of a phosphorous acid or a mixture of such salts is added to rubber either as latex or in its plastic form. When mixed with rubber this salt acts as an accelerator of vulcanisation; when with latex, it acts as an accelerator and as a preservative. The group of salts available for the purpose is typified by hydrated tri-potassium phosphate, trisodium phosphate, potassium pyrophos-

phate, secondary sodium phosphite, sodium ammonium hydrogen phosphate, secondary ammonium phosphate, sodium pyrophosphate, secondary sodium phosphate, disodium phosphate. The phosphorous acid salt is combined with the rubber in the proportion of 3 per cent. or less. Other compounding ingredients may be added with the phosphorous acid salt to latex but such salts efficiently preserve latex which is free from or deficient in other preservatives.

(2) The General Rubber Company
F.M.S. Grant No. 498 (1926)
Improvements in or relating to Method of preserving Latex and Products obtained thereby

Latex is preserved by the addition of an organic antiseptic and of an alkaline phosphate. The compounds preferred are formaldehyde and trisodium phosphate respectively, the former being used in sufficient quantity to prevent bacterial action and the second in sufficient quantity to reduce the hydrogen ion concentration below 1×10^{-7}. These quantities will be of the order of 0.5 per cent. of formaldehyde and 1.5 per cent. of trisodium phosphate.

(3) United States Rubber Plantations
F.M.S. Grant No. 537 (1928)
A new Method of treating Latex and the Products therefrom

A light-coloured and substantially transparent rubber is obtained by treating latex in such a manner that the protein constituents are decomposed without coagulation taking place and subsequently subjecting it to a spray-drying process. The compound preferred for treating the latex is a ten per cent. solution of the sodium salt of sulphonated undecylinic acid added to an amount equal to about five per cent. of the rubber content of the latex. After the decomposition has reached the desired stage it may be prevented from proceeding further by the addition of any appropriate material, such as formaldehyde. At this stage also an acid may be added such as phosphoric or picric acids or a phenol, such as cresol.

(4) Naugatuck Chemical Co.
F.M.S. Grant No. 627 (1928)
Process for treating Rubber Latex

The object of the process is to obtain a rubber which has the milling properties of rubber obtained by coagulation combined with the tensile properties of spray-dried rubber. This is effected by spray-drying latex in which has been incorporated an easily hydrolyzable salt of a fixed acid and a volatile base. The salt is used in quantities sufficient to give a distinct acid reaction to the water extract of the dried rubber. If the salt itself gives a reaction on the acid side of neutrality it is necessary to add to the latex a

certain amount of a volatile base to prevent coagulation. Thus if tertiary ammonium phosphate is the salt used this alone will prevent coagulation but if primary ammonium phosphate is used, there is also added an amount of ammonia sufficient to give the desired alkalinity. The preferred base is ammonium and the preferred acid is phosphoric but oxalic and citric acids may also be used.

(5) Naugatuck Chemical Co
F.M.S. Grant No. 652 (1930)
Preservation of Latex

Latex is preserved on the acid side of neutrality by the addition of saponin or similar glucosides such as arbutin or salicin, having the general formula $Cn\ H_2n-_8Ox$ (x=10 or 7). H_2n-_8Ox. The preserving power of saponin, which functions as a protective colloid, will prevail throughout a range of hydrogen ion concentration in the latex, of increasing acidity, from pH 7 to pH 1. Good results are obtained with amounts from $\frac{1}{2}$ to 4 parts of saponin per 100 parts of rubber. The method may be applied to the treatment of alkaline preserved latex provided that the effect of the alkaline preservative is nullified by removal or conversion.

(6) Naugatuck Chemical Co
F.M.S. Grant 653 (1930)
Method of preserving Latex

Latex is preserved by the addition of a small amount of a soluble salt of selenious or tellurious acid i.e. of a soluble salt of an acid having the formula H_2XO_3 where X represents selenium or tellurium.

(7) Naugatuck Chemical Co
F.M.S. Grant No. 663 (1930)
Preservation of Latex

The known action of phenols in preserving latex is enhanced by the addition of small quantities of certain aliphatic hydrocarbons which are not, in themselves, protective bodies. The preferred aliphatic hydrocarbons are kerosene and gasoline. Suggested quantities for effective preservation are 0.1 per cent. of phenol with 0.5 per cent. of kerosene.

(8) Naugatuck Chemical Co.
F.M.S. Grant No. 677 (1931)
Improvements in Process for treating Rubber Latex and Product

Rubber latex is treated with an easily hydrolyzable compound of a volatile acid and a volatile base in quantity sufficient to give on drying a rubber of which the water extract has a pH not over 7. The salt is selected from the group comprising ammonium chloride,

bromide, fluoride and nitrate. The rubber obtained from the treated latex by spray-drying shows marked improvement in physical properties over ordinary spray-dried rubber and when vulcanised it shows a greatly improved flexing ability. When combined with fibrous material the vulcanised rubber has a greatly extended life.

(9) Naugatuck Chemical Co.
F.M.S. Grant No. 678 (1931)
Improvements in the Treatment of Latex

Latex is stabilised without the addition of metals or with subsequent increase in viscosity by treatment with oxygen compounds. The application of heat or pressure are optional modifications but the pH must be above 7. Instead of oxygen it is possible to use oxygen-yielding substances which are free from polyvalent electropositive ions e.g. the latex is treated with sodium perborate and ammonia. Latex thus treated possesses higher chemical stability than latex stabilised by normal methods. Rubber produced from this latex by spray-drying also has modified properties such as a higher breakdown, a higher acetone extract and greater plasticity than normal spray-dried rubber.

(10) Naugatuck Chemical Co.
F.M.S. Grant No. 703 (1931)
Improvements in or relating to the Preservation of Rubber Latex

Latex preserved by the addition of formaldehyde and ammonia, separately and in the order named at suitable intervals, possesses properties superior to latex preserved with either alone or with a mixture of the two added simultaneously. The time allowed to elapse between the two steps of the treatment should be such as to ensure that no substantial excess of formaldehyde remains when the ammonia is added and hence the amount of the accelerating substance formed by interaction between formaldehyde and ammonia is reduced to a minimum. Perfect preservation is produced at a reduced cost.

(11) I. G. Farbenindustrie A.G.
British Patent 289,022
Application date Mar. 30, 1928
Complete accepted May 17, 1928
Registered in F.M.S. No. 66 (1927)
Improvements in the Preservation of Latex

Latex is preserved by the addition of water-soluble neutral or alkaline salts of ester acids, more especially those of mineral acids, such as diarylphosphoric acids or methylsulphuric acid. Latex treated in this way possesses the advantage of giving more even dispersions of fillers and other compounding ingredients and also of giving products of higher mechanical strength.

(12) J. Y. Johnson from I. G. Farbenindustrie A.G.
British Patent 294,412
Application date Nov. 12, 1927
Complete accepted July 26, 1928
Registered in F.M.S. No. 85, 1927
Improvements in the Preservation and Treatment of Latex

Latex is preserved by the addition of a salt of a sulphonic acid possessing soap-like properties. These sulphonic acids may be of the aromatic or hydro-aromatic type, containing alkyl cycloalkyl, or aryl groups as substituents or may be the true sulphonic acids (in contradistinction to the sulphuric acid esters) obtained by the sulphonation of tars, mineral oils, fatty acids and similar substances. This method of preservation is of advantage in impregnating materials with latex since latex thus treated is readily distributed over the surface and penetrates quickly into the pores.

(13) J. Y. Johnson from I. G. Farbenindustrie A.G.
British Patent No. 300,456
Application date Feb. 12, 1928
Complete accepted No. 15, 1928
Registered in F.M.S. No. 67, 1928
Improvements in the Preservation and Treatment of Latex

The method of preservation covered in the foregoing patent is improved by the simultaneous addition to the latex of aliphatic or aromatic alcohols which may also contain halogen as a substituent, ketones, hydrocarbons, or halogen or nitro or amino derivatives of hydrocarbons. Latex thus preserved does not coagulate on the addition of fillers and also penetrates very readily into the pores of fabric or other materials with which it is desired to impregnate latex.

Section II

Concentration of Latex by centrifugal Machines

(1) W. L. Utermark
British Patent No. 219,635
Application date Nov. 23, 1923
Complete accepted Dec. 24, 1924
Registered in F.M.S. No. 4, 1923
Process for preparing concentrated Milk Sap

The latex is separated by centrifugal action into two homogeneous layers the one possessing a much higher concentration of rubber than the other. From a latex of 35 per cent. D.R.C. a portion of at least 45 per cent. D.R.C. may be obtained. A centrifuge of any known type may be used characterized in this that it has a speed of 5,000 to 10,000 revolutions per minute. In the example given the original latex is preserved with ammonia.

(2) Dunlop Rubber Co. Ltd., Utermark and others
British Patent No. 319,410
Application date April, 26, 1928
Complete accepted September 26, 1928
Registered in F.M.S. No. 95, 1928
Improvements in or relating to the Preparation of concentrated India Rubber Latex

Ammonia is added to the latex in quantities lying between 0.1 and 0.3 per cent. before centrifuging and the ammonia content of the concentrate produced is made up to 0.3 or 0.4 per cent. This improvement may be applied to any process which is according to the preceding patent and, in particular, to that process using an Alfa-Laval Centrifuge. The claims also cover the product i.e., concentrated rubber latex prepared by the process and further products therefrom, particularly compounded rubber latex.

Section III

CONCENTRATION OF LATEX BY CREAMING

(1) Isidor Traube
British Patent No. 226,440
Application date May 29, 1924
Complete accepted Dec. 24, 1924
Registered in F.M.S. No. 13, 1924
Improvements relating to the Production of concentrated Rubber Latex and of Rubber from Rubber Latex

Latex is creamed by the addition of organic colloids such as carragheen moss, Iceland moss or vegetable mucilages. The following examples are given :—

(i) To 100 litres of fresh latex, is added the extract made by heating 140 gms. of carragheen moss with 14 litres of water and straining the solution. After stirring, the latex is left at rest for some hours or longer at 50°-60°C during which time two layers are formed, the upper one containing practically all the rubber substance.

(ii) A jelly made by heating 100-200 gms. of gelatin with 1 litre of water, is allowed to cool and upon it is poured 1 litre of latex cream. After one or more hours, a cake of rubber can be lifted from the gelatin.

(iii) One litre of cream of 50-60 per cent. dry rubber content is mixed with 300 gms. of calcium carbonate and about 100 gms. of sulphur. The mixture is dried as in example (ii) and vulcanised.

(2) General Rubber Company
British Patent No. 294,002
Application date Aug. 25, 1927
Complete accepted July 19, 1928
Registered in F.M.S. No. 58, 1927
Method of treating Rubber Latex

Latex is treated with a salt of alginic acid and allowed to separate into two layers. The upper layer of cream may be converted into dry rubber by spray drying in any suitable apparatus, or by drum drying or by other suitable methods.

In an example, ammoniated latex is treated with a 5% solution of ammonium alginate in an amount calculated to give 0.2 parts of solid alginate per 100 parts of rubber in the form of latex.

(3) Naugatuck Chemical Company
F.M.S. Grant No. 523, 1927
Improvements in or relating to Methods of treating Latex and Products thereof

Latex is creamed by means of nonhydrolised vegetable colloids such as pectin, Irish moss, Karaya gum, etc. The creaming agent is prepared and used in a substantially unhydrolysed condition. The cream so obtained can be subsequently heated to hydrolyse the creaming agent and reduce the viscosity of the product. Where heating is practised, it is best to stabilise the latex with saponin or soaps.

(4) Naugatuck Chemical Company
F.M.S. Grant No. 629, 1929
Treatment of Latex

Latex is treated with substances of the type M-halogen-O, where M is alkyl, alkali metal, alkali earth metal or hydrogen. The particular substance of this type, to which reference is made, is sodium hypochlorite. By the use of such a body, latex can be caused to cream, stability can be increased, and a tacky rubber can be produced at will. Activity can be varied by causing variation in hydrogen ion concentration. Weak acids such as boric, cinnamic and carbon dioxide, may be used to vary the hydrogen ion concentration. The action of the hypochlorite may be checked at will by the addition of sodium thiosulphate.

(5) Naugatuck Chemical Company
F.M.S. Grant No. 659, 1930
Treatment of Latex

In order to overcome the tendency of creamed latex to cream further on standing, an anti-creaming agent is added to the cream.

In an example, saponin is used as the anti-creaming agent and is added in the proportion of one part of saponin per 100 parts of cream solids.

(6) Naugatuck Chemical Company

F.M.S. Grant No. 664, 1930
A Method of concentrating Rubber Latex

The speed with which creaming takes place under the influence of organic colloids can be greatly increased if the creaming is carried out in the presence of an acid or an alkali in such small quantity as not to cause coagulation. Weak organic acids such as citric, tartaric, malic and lactic acids are specifically mentioned. The use of pectin bodies together with weak organic acids is described. Centrifugal action or heat may be used to accelerate the rate of separation. In order more completely to remove serum constituents, the cream may be redispersed in water and re-creamed.

(7) Naugatuck Chemical Company

F.M.S. Grant No. 665, 1930
Method of concentrating Latex and removing non-rubber Constituents therefrom

Latex is treated with a known creaming agent and then subjecting it, either while standing or flowing, to an electric potential or strain developed from direct or alternating current. The latex may be shocked, or subjected to the current for a short time or continuously. The electrode surfaces in contact with the latex may be covered with an insulating material to restrict the flow of current. The rate of creaming is increased.

(8) K. D. P. Ltd.

British Patent No. 337,269
Application date (in United Kingdom); Jan. 24, 1929
Complete accepted Oct. 30, 1930
Registered in F.M.S. No. 125, 1929
Process of concentrating Latices

Latex is treated with mucilages such as diagum or similar substances adapted to combine with water without previous hydrolysis, and is then heated either in an autoclave or by means of live steam to a temperature substantially above 60°C. for periods of the order of ½-1 hour. After heat treatment, creaming takes place in a few hours. Cream separation may be accelerated by centrifuging or filtration.

Section IV

Concentration of Latex by Evaporation

(1) G. Parry Davis
F.M.S. Grant No. 376, 1923
Davis Process of Condensation of Rubber Latex un-vulcanised or vulcanised

Latex is combined with each or any of the following types of substance (1) a dispersoid (2) a germicide (3) an emulsifying agent (4) a strengthening agent (5) a thickening agent (6) a stabilising agent (7) a vulcanising agent. The mixture is then subjected to heat, agitation, concentration by evaporation and subsequent cooling. Evaporation is effected in a vacuum pan (of unspecified type or working-conditions) over a period of three hours during which time about 75 per cent. of its bulk of water is removed.

(2) K. D. P. Ltd.
F.M.S. Grant No. 457, 1925
Process and Apparatus for concentrating Caoutchouc and the like Latices

Concentration is effected by evaporating latex which is spread in a thin layer on a moving surface such as a rotating drum and further minimising the tendency to coagulation by the addition of protective colloids. Full details are given of various alternative methods for heating the surface, for effecting the spreading of the latex and for maintaining the layer of latex at a constant thickness.

(3) V. K. Singhan
F.M.S. Grant No. 536, 1927
Improvements in the Art of concentrating Rubber Latices and the Products thereof

Concentration is effected by evaporation in any known type of evaporator, preferably of tube film type, coagulation being prevented by the addition of certain alkalies and colloidal materials. (This patent was revoked after a legal action.)

(4) V. K. Singhan
F.M.S. Grant No. 601, 1929
Additions to and Improvements in the Art of concentrating Rubber Latices and the Products thereof

Addition to the above, covering means of compounding the resulting concentrated latex.

(This patent was revoked after a legal action.)

(5) K. D. P. Ltd.

British Patent No. 293,771
Application date July 11, 1928
Complete accepted Oct. 10, 1929
Registered in F.M.S. No. 127, 1929
Process for concentrating natural Latices

In concentrating latex by evaporation alkali salicylates are added as stabilisers. The concentrate obtained is very much less alkaline than that normally obtained e.g. by the use of very alkaline soaps as stabilisers.

(6) Dunlop Rubber Co., Ltd.

British Patent No. 307,315
Application date Sept. 3, 1928
Complete accepted Mar. 4, 1929
Registered in F.M.S. No. 71, 1927

An improved Method and Apparatus for concentrating or drying Liquids

The latex is caused to spread in a thin layer or film on a surface by giving the surface an oscillatory motion. The latex and/or a current of air or gas over the surface are heated and the process may be carried out under reduced pressure. Details and drawings are given of apparatus which gives to the evaporating surfaces the desired motion *without* rotating the vessel or any inner drum. The specification is drafted in such a manner as to stress the differences between this invention and the K.D.P. Revertex method.

(7) Dunlop Rubber Co., Ltd. Murphy and Twiss

British Patent No. 324,375
Application date July 26, 1928
Complete accepted Jan. 27, 1930
Registered in F.M.S. No. 102, 1930

Improvements in or relating to the Production of reversible Latex Compositions

Latex is concentrated by evaporation to a water content of fifteen per cent., stabilisation being effected by protective colloids such as soaps together with one or more non-coagulating aliphatic hygroscopic substances. The substances added are polyhydric compounds particularly polyhydric alcohols such as glycerol, glycol, diethylene glycol or alkyl ethers of these such as glycyl mono-ethyl ether.

(8) Revertex Ltd.
British Patent No. 363,872
Application date Jan. 29, 1931
Complete accepted Dec. 31, 1931
Registered in F.M.S. No. 140, 1931
Process for the Production of Rubber Latex Concentrates

The preparation of concentrates of 70-85 per cent. of dry substance is effected in the most economical manner and the highest stability is obtained if caustic potash or other non-volatile caustic alkali is added before and/or after concentration is complete. The alkali content in the concentrate is adjusted to a figure of 80-180 milli-equivalents, and preferably 115—125 milli-equivalents, per kilogram of concentrate.

(9) Metallgesellschaft A.G.
British Patent No. 382,235
Application date May 9, 1932
Complete accepted Oct. 20, 1932
Registered in F.M.S. No. 147, 1933
Process for inspissating or concentrating Rubber Latex

Latex, treated with anti-coagulants is warmed under conditions precluding the formation of steam and is then introduced, in such a way as to present a large superficial area, into an evaporation chamber in which the pressure is lower than the vapour pressure of the latex at its admission temperature. The pressure in the evaporating chamber is preferably not exceeding 50 mm. of mercury and also is preferably 300 mm. less than the pressure in the heating chamber. The apparatus is described in detail.

Section V

Latex Concentration by Filtration

(1) Societa Italiana Pirelli and U. Pestalozza.
British Patent No. 344,875
Application date Nov. 8, 1929
Complete accepted Mar. 9, 1931
Registered in F.M.S. No. 139, 1931
Improved Method and Means of Concentration of Rubber Latices and other aqueous Dispersions of Rubber

Concentration is effected by the removal of water and dissolved substances by filtration. The apparatus is so designed that the filtering medium and the latex move relatively to each other at such a speed that the pores of the medium are maintained substantially free for the passage of the aqueous filtrate. The direction of the

relative motion may be changed periodically in order to ensure further against the pores of the filtering medium becoming choked. The method, the product, and various forms of apparatus are covered.

(2) V. K. Singhan
F.M.S. Grant No. 705, 1931
Improvements in the Production of Rubber Pastes

An acid free reversible concentrate is produced by previously diluting and then filtering or ultrafiltering the diluted latex to which known alkali stabilisers have been added, such as alkali fluorides, salicylates or hydroxides. Substances such as fillers or other compounding ingredients are added to the concentrate in the form of a paste with the filtrate, thereby returning to the concentrate the valuable serum products.

Section VI

COMPOSITIONS OF LATEX WITH OTHER MATERIALS

(1) George C. H. Laub
F.M.S. Grant No. 215, 1921
The Manufacture from Latex of a Coagulum which can be vulcanised immediately after drying and washing and which includes ingredients imparting specific required qualities to the Rubber when vulcanised.

Sulphur, vulcanising agents and any chemicals which will impart specific properties are added to latex which is coagulated with acetic acid after stirring. The coagulum is rolled into sheets or otherwise moulded, dried and vulcanised.

(2) George C. H. Laub
F.M.S. Grant No. 216, 1921
The Manufacture from Latex of a Coagulum which can be vulcanised immediately after drying and washing

Sulphur and/or vulcanising agents are added to latex which is coagulated after stirring. The coagulum is rolled into sheets or otherwise moulded, dried and vulcanised.

(3) A. Jeffrey and B. Wilkinson
F.M.S. Grant No. 334, 1923
A Process for the Conversion of Rubber Latex of any degree of Specific Gravity into non-oxidisable Rubber Composition, Tiles, Mats, Wall, Floor and Roof Coverings and Products of a similar Character

Sulphur, with oxides and/or sulphides of lead, antimony, magnesium and zinc are added to latex. Cement and dyes may also be added. After stirring, the mixture is rotated in a suitable

vessel until coagulation takes place. The coagulum is machined, surface treated with sodium silicate, dried and built up to the desired shape.

(4) B. Wilkinson
F.M.S. Grant No. 380, 1924
Improvements in or relating to the Manufacture of Rubber Composition from Rubber Latex

Latex is treated with sulphur and oxides, and/or sulphides as in Federal Grant No. 334. Colouring matters and fillers such as china clay and cement may also be added. Sodium silicate may be added to prevent premature coagulation. Coagulation is effected by paddles or by churning as in Federal Grant No. 334. The coagulum is machined into sheets. Surface treatment and subsequent operations are as in Federal Grant No. 334.

(5) B. Wilkinson
F.M.S. Grant No. 519, 1927
An improved Method for the Manufacture of Rubber from Rubber Latex

Latex is treated with an aqueous solution of an alkali, the alkalinity of the mixture is adjusted to pH 10, and the whole is allowed to stand for 18 hours. Chemicals are then added and the mixture is allowed to stand for a further 24 hours. Coagulation is induced by stirring and the coagulum is machined in known manner. It is claimed that the sulphur naturally occurring in latex is rendered available for combination with the caoutchouc.

(6) Dunlop Rubber Co., Ltd.
Federal Grant No. 529, 1928
Improvements in or relating to the Manufacture of Rubber Articles

Latex compounded with sulphur, zinc oxide, a suitable accelerator, a colour and other filling ingredients is sprayed from a nozzle on formers or moulds of any desired shape. Drying is accomplished by means of a current of hot gas. The article may be vulcanised in any suitable manner.

(7) Dunlop Rubber Co., Ltd.
F.M.S. Grant No. 530, 1928
Method for the Production of Rubber Goods directly from Latex

The outer surface of a mould is coated with a layer of molten or fluid jelly, which jelly contains a coagulant such as sodium silicofluoride or salts of polyvalent metals such as calcium, magnesium zinc or aluminium. The coated mould is immersed in latex or con-

centrated latex or compounded latex and withdrawn. The coagulated film so obtained is dried and may be vulcanised in known manner if desired.

(8) Dunlop Rubber Co., Ltd.
F.M.S. Grant No. 557, 1928
Improvements in the Manufacture of Rubber and similar vegetable Resins

Compounding ingredients preferably in the form of aqueous dispersions are added to latex in presence of stabilisers and evaporation to thick creams or pastes is carried out while subjecting the mixture to gentle continuous dispersive agitation. The products are substantially free from agglomerates of the various ingredients, and concentration may be carried to a stage at which the compounding ingredients no longer tend to settle out on storage. A number of suitable compounding ingredients are named; these comprise the bodies used in normal rubber practice. Stabilisers such as glue, gelatine, casein vegetable gums, dextrin, soap and sodium silicate may be used.

(9) Dunlop Rubber Co., Ltd.
F.M.S. Grant No. 573, 1928
Method for the Production of Articles substantially made of organic Materials from aqueous Dispersions containing the said organic Materials

Porous moulds are dipped into suitable coagulants and the excess of coagulant drained off. The moulds are then dipped into suitably compounded or filled latex. Suction is applied to the interior of the mould or pressure to the latex dispersion itself, in order to shorten the dipping period. The mould is removed and dried. The article is then vulcanised.

(10) Dunlop Rubber Co., Ltd., D. F. Twiss, F. T. Purkis and E. A. Murphy
British Patent No. 324,104
Application date Oct. 18, 1928
Complete accepted Jan. 20, 1930
Registered in F.M.S. No. 103, 1928
Improvements in or relating to the Manufacture of Rubber Articles

Latex is compounded with normal filling materials together with small amounts of substances which do not individually produce coagulation but which react when the temperature is raised to produce substances having coagulative properties and so cause gelling. Suitable substances are ammonium persulphate with trioxymethylene, formaldehyde, acetaldehyde and paraldehyde. The oxidation which takes place on heating yields acidic coagulants. Ammonium or

barium thiosulphates together with a small proportion of lead acetate may also be used.

(11) Dunlop Rubber Co., Ltd., W. H. Chapman and D. W. Pounder

British Patent No. 326,497
Application date Nov. 14, 1928
Complete accepted March 14, 1930
Registered in F.M.S. No. 106, 1928

Improvements in or relating to the Manufacture of Goods of Rubber or similar Material

Goods are manufactured from latex which has been rendered sensitive to heat by the addition of gelling agents such as ammonium persulphate and trioxymethylene, as described in British Patent No. 324,104. A former may be dipped in the latex and then heated in hot water or steam; the treated latex may be spread on cloth and subsequently passed into a hot air chamber; the treated latex may be extruded through a die into hot water.

(12) Dunlop Rubber Co., Ltd., E. A. Murphy and D. F. Twiss

British Patent No. 327,451
Application date Jan. 5, 1929
Complete accepted April 7, 1930
Registered in F.M.S. No. 108, 1929

Improvements in or relating to the Manufacture of Goods of Rubber or similar Material

Latex is treated with compounding ingredients in such a manner as to produce crumb-like masses. These may be consolidated and incorporated with rubber on a mill or compressed to form leather like masses. The process of compounding is carried out in two stages. In the first stage certain ingredients are added to latex as aqueous dispersions in the presence of a stabilizer and thoroughly mixed; sufficient stabilizer is present at this stage to protect the latex from the coagulating effect of the added ingredients such as gas black, clay, silica or whiting. After thorough mixing, the remaining bodies such as zinc oxide, lime or magnesia are added as aqueous dispersions; the protective influence of the stabilizer is overcome and thickening and crumbing take place on further mixing. The crumb is dried and is then ready for use.

(13) Dunlop Rubber Co., Ltd., W. H. Chapman, D. W. Pounder and E. A. Murphy
British Patent No. 332,525
Application date March 21. 1929
Complete accepted July 21, 1930
Registered in F.M.S. No. 130, 1929

Improvements in or relating to the Manufacture of Goods of Rubber or similar Material

Goods of sponge or cellular structure are manufactured from compounded latex. The latex containing vulcanising ingredients is in the form of a viscous cream. It contains also a froth forming substance such as ammonium oleate or saponin which will give a stiff froth, and a coagulant such as sodium silicofluoride which is of the delayed action type. The mix is whipped into a foam, poured into moulds of any desired shape and the foam is allowed to set. The products may then be vulcanised.

(14) Dunlop Rubber Co., Ltd., E. A. Murphy and E. W. B. Owen
British Patent No. 332,526
Application date March 21, 1929
Complete accepted July 21, 1930
Registered in F.M.S. No. 131, 1929

Improvements in or relating to the Manufacture of Goods of Rubber or similar Material

Foams are prepared as in British Patent No. 332,525 but without the addition of the coagulant or gelling agent. The foam suitably deposited in moulds, or on fabric, is subsequently caused to set by evaporation or other means.

Section VII

Impregnation of Fibres with Latex

(1) E. Hopkinson
F.M.S. Grant No. 270, 1922

Improvements in Processes for the Production of Fabrications of Rubber and filamentary Materials and Products obtained therefrom

Yarn or fabric is passed through a bath of latex and dried. Before drying, excess latex may be removed by squeezing between rolls. For better penetration, the yarn may be placed in a chamber which can be exhausted, before admission of the latex. Vulcanising ingredients may be added to the latex or concentrate. Apparatus is described for the manufacture of impregnated tyre cord.

Section VIII

Electro-deposition of Rubber

(1) Anode Rubber Company Ltd.
F.M.S. Grant No. 373, 1924
Process and Device for the immediate Production of mechanically unworked pure Rubber Sheets from Latex

Latex preserved with ammonia is treated in a centrifugal machine of the skimming type run at a suitable speed and arranged to remove a concentrate layer of suitable thickness. By this means a concentrate is obtained which is free from impurities and which contains 50-60% of dry rubber. The concentrate may be coloured by the addition of dyes before centrifuging. The concentrate is subjected to electrophoresis upon a base having anodic properties. The anode is constructed of materials such as amalgamated zinc which are corroded to minimum extent by oxygen and liberated acid ions. The anode can take the form of an endless band from which the deposited rubber is continuously removed.

(2) Anode Rubber Company Ltd.
F.M.S. Grant No. 374, 1924
Process and Device for the direct Production of Rubber Sheets and moulded Articles from Latex

Rubber is deposited from centrifuged latex on to a porous non-conducting base, which is permeable to liquids and separated from the anode by a layer of electrolyte having an acid reaction. The electrolyte is in communication with the external air. Alternatively the permeable non-conducting base may be separated from the anode by an electrically non-conductive permeable diaphragm impregnated with electrolyte. The oxygen evolved escapes freely and articles of any desired thickness may be produced which are homogeneous and compact and which are not spongy. The bases or moulds may preferably be made of unglazed earthenware and the anodes of carbon. Sulphur and compounding ingredients may be mixed with the latex before the commencement of electro-deposition. Various types of bases are described.

(3) Anode Rubber Company Ltd.
F.M.S. Grant No. 453, 1925
Improvements in the Manufacture of Rubber Goods from Rubber Emulsions

An improvement on the process described in Federal Grant No. 374 above. Further means are provided for preventing contact and occlusion of liberated gases with the deposited rubber. The anode or other parts of the apparatus may be constructed to absorb the gases; the electrolyte may be adapted to yield no gaseous products

during electrolysis; soluble sulphur compounds such as polysulphides may be added to the rubber dispersion so as to give a deposit of sulphur at the anode; a permeable partition may be arranged to shut off the rubber dispersion from the chamber containing the cathode and cathode electrolyte, in order to prevent gas bubbles liberated at the cathode from reaching the deposit.

(4) Anode Rubber Company Ltd.

F.M.S. Grant No. 454, 1925

Improvements in the direct Production of Rubber Goods from Rubber Emulsions

Describes various means of overcoming the difficulties of incorporation of various solid and liquid vulcanising and compounding ingredients into latex which is intended to be used for electrolytic deposition. Hydrocarbon and other oils are impregnated upon diatomaceous earth—Kieselguhr—before addition to latex; lead oxide which tends to settle quickly on account of its high specific gravity is melted with Kieselguhr and the disintegrated product is then added to latex; sulphur is mixed with Kieselguhr, lamp black or similar bodies before addition to latex; sulphur may also be heated with vulcanizable oils before dispersion.

(5) Anode Rubber Company Ltd.

British Patent No. 252, 673
Application date (in U.K.) Feb. 23, 1926
Complete accepted May 23, 1927
Registered in F.M.S. No. 47, 1925

Method for the Production of Rubber Goods directly from Latex

Rubber is deposited from latex or concentrate on to a porous dipping mould, not by electrophoretic methods, but by acceleration of the passage of water from the side of the mould which is in contact with the latex, to the side remote from the latex; the side of the mould remote from the latex may be heated or rapid air circulation may be induced to achieve this end; a reduced pressure may be produced on the inner side of hollow moulds; water absorbing bodies such as cement or gypsum may be applied to that side of the mould which is not to receive the deposited rubber. Substances such as acetic and other acids which do not absorb water but which promote agglomeration may be allowed to diffuse through the moulds towards the side which is to receive the deposited rubber. Compounding ingredients may be added to the latex to be treated.

(6) Anode Rubber Company Ltd.
F.M.S. Grant No. 506, 1927

Improvements in the Method of and Apparatus for the Manufacture of Rubber Goods from Rubber Dispersions by electrophoretic Means

In the manufacture of closed hollow articles such as tubes it may be impracticable to use deflecting diaphragms or partitions to prevent cathode gases from reaching the deposit and impairing its uniformity. The invention describes means of overcoming this difficulty. The cathode is surfaced with a metal oxide which is easily reduced; the hydrogen liberated reduces the peroxide coating. The cathode is preferably of lead which is coated with lead peroxide after the manner of the plates of a storage battery; when the peroxide coating is spent, the cathode surface may be re-oxidised and used again. Apparatus for the manufacture of inner tubes is described.

(7) Dunlop Rubber Co., Ltd.
F.M.S. Grant No. 527, 1928

Improvements in or relating to the Manufacture of Rubber Articles

Articles are formed on a mould by electro-deposition from compounded latex. After drying in hot air, they are finally heated in a press carrying a mould designed to impress upon the article any desired pattern or mark. The vulcanisation may be completed in the press.

(8) Rubber Electro-deposition Patents Ltd.
F.M.S. Grant No. 533, 1928

Improvements in or relating to the Production of Rubber

In order to obtain an anodic deposit, free from gas holes or porosity, the rubber deposition may be effected intermittently; the current may be passed at intervals, and the mould may be intermittently removed from the latex either by raising it from the latex or removing the latex bath away from the mould. By intermittent deposition, gas is allowed to escape and the deposit is homogeneous. The length of time of exposure to air varies with the current density employed. In producing tubes, the mould to receive the rubber may be partly immersed in the latex and continuously rotated, so that the deposit is intermittent and is exposed to atmosphere at regular intervals.

(9) Dunlop Rubber Co., Ltd.
F.M.S. Grant No. 551, 1928
Improvements in the direct Production of Rubber Goods from Rubber Dispersions

In order to obtain anodic deposits of considerable thickness it is necessary to establish conditions under which the resistance of the deposit itself will not become so great as to cut off the current and prevent further deposition. If soft soap is added to the latex, concentrate, or compounded latex, before electrophoresis, in amounts considerably greater than those used for preservation, thick tough deposits may be obtained without the undesirable increase in electrical resistance.

Section IX

VULCANISATION OF LATEX

(1) P. Schidrowitz
F.M.S. Grant No. 256, 1922
Improvements in or relating to the Manufacture of Rubber

Latex, preserved in an alkaline condition, is treated with vulcanising ingredients and is then vulcanised by heat, in known manner. The added sulphur may be in the solid form or as sodium polysulphide. Zinc oxide, accelerators, fillers and pigments may also be added. The vulcanised latex may be coagulated, and the rubber built up into desired forms.

(2) D. Graham and R. W. Kendall
F.M.S. Grant No. 475, 1926
Cold Process for vulcanising Rubber Latex

Calcium disulphide prepared by the combination of calcium hydroxide and sulphur, is added to latex. Filling materials may also be added. Various uses are described for latex so treated.

(3) I. G. Farbenindustrie A.G.
British Patent No. 288,206
Application date (in U.K.) April 2, 1928
Complete accepted August 23, 1928
Registered in F.M.S. No. 65, 1927
Improvements in the Vulcanisation of Latex

Latex is treated with dispersion media such as aromatic sulphonic acids or their salts and is then treated with sulphur dioxide and hydrogen sulphide as in the Peachey process for cold vulcanisation of rubber. Examples of suitable dispersion agents are the condensation products obtainable from naphthalene, formaldehyde and sulphuric acid.

(4) G. P. Davis
F.M.S. Grant No. 698, 1931
Improvements relating to Vulcanisation

Chlorophyll is added to mixes of rubber, rubber or latex with sulphur or other vulcanising agents. Preferably 3 per cent. zinc oxide should be present. It is suggested that chlorophyll has the power of collecting, storing and utilising the energy of sunlight, and of causing the vulcanising agents to become abnormally active and effective for vulcanisation.

Section X

SPRAY DRYING OF LATEX

(1) E. Hopkinson
F.M.S. Grant No. 188, 1920
Process for treating Rubber-containing Latex

Latex is subjected, in a finely divided form, to a drying medium such as a stream of heated gas. The rubber is thus obtained as a dry powder containing all the non-rubber constituents of the original latex. By subsequently pressing or rolling the powder, it is compacted into a solid block. The advantage over normal methods are (1) an increased yield of rubber (2) the absence of the chemicals normally introduced as coagulants (3) the better tensile and abrasive properties conferred on the rubber by the retention of the whole of the non-rubber constituents. If desired, vulcanising ingredients may be added to the latex before spraying and premature coagulation may be avoided by the addition of a protective agent.

(2) E. Hopkinson
F.M.S. Grant No. 194, 1920
Crude Rubber and Rubber Products obtained from Rubber-containing Latex produced by finely spraying such Rubber-containing Latex and drying and compacting the comminuted Latex so formed

A crude rubber is derived from substantially dry masses of the solid contents of latex obtained by drying and compacting comminuted latex. (This grant covers the various forms of rubber produced by the processes covered by Grant No. 188).

(3) General Rubber Company
F.M.S. Grant No. 276, 1922
Improved Process and Apparatus for treating Rubber Latex and similar Material

In the normal method of spray-drying latex the particles produced by air spraying are not infrequently not of uniform size and the cost of compressing air or spraying is high. Under this

specification these difficulties are eliminated by feeding latex on to a moving surface, such as a circular disc, from the edge of which it is discharged as a curtain of comparatively uniform fine particles. The heating gas is maintained at a temperature above 240°F and travels slowly in the same direction as the latex spray.

(4) General Rubber Company
F.M.S. Grant No. 370, 1924
Improvements in or relating to Apparatus for drying Rubber Latex and similar Materials

The apparatus covered by Grant No. 276 is improved by devices which permit of continuous withdrawal of the integrated deposit of dried latex and which also shield the operatives from the excessive heat associated with the earlier apparatus.

(5) E. Hopkinson
F.M.S. Grant No. 410, 1924
Process and Apparatus for obtaining Rubber from Latex

In this improved process the spraying of the latex is effected by maintaining a high degree of pressure at least 200 lbs per square inch, in the latex itself while in the container from which it is sprayed. The latex issues in two streams which are sprayed by their mutual impact in opposition. The heating medium is hot air mingled with the products of combustion from a furnace. The pump operating on the latex and the arrangement of the latex orifices are described in detail.

(6) General Rubber Company
F.M.S. Grant No. 429, 1925
Improved Manufacture of crude Rubber

By subjecting rubber produced by a spraying process to heat a dark-coloured rubber is produced which is soft, plastic and tacky and which requires a minimum of time and power in the breaking down and mixing operations. The heating may be effected during the spraying and/or may be applied beneath the floor or surface on which the dried rubber particles collect.

(7) General Rubber Company
F.M.S. Grant No. 507, 1927
Improvements in or relating to Apparatus for drying Rubber Latex and similar Substances

The apparatus is more compact and more easily assembled than the earlier forms. It comprises a drying chamber, means adjacent to the centre of the top for supplying in comminuted form the liquid to be dried, means for supplying a drying medium to the chamber and exhaust openings at the bottom of the chamber. It embodies

the following characteristic features (1) separate downwardly directed inlets for the drying medium are spaced inwardly from the side wall of the chamber and from each other (2) a supply chamber for the drying medium above the drying chamber and spaced annular openings leading downwardly therefrom into the drying chamber (3) a perforate screen separating the supply chamber from the drying chamber and imperforate members disposed on the screen to define the said annular openings.

(8) A. Meinesz
F.M.S. Grant No. 682, 1930

New Apparatus for making Rubber and the like in the form of a Sheet by atomising and drying Latex

This is a new form of apparatus for making sheet rubber by spraying latex and subsequently pressing the layer of dried rubber. It is distinguished from the forms of apparatus previously in use by its property of atomising the latex in an extremely fine condition by means of a number of small atomisers fixed in a long narrow heated tunnel. These atomisers are arranged opposite each other and at an angle with the length direction of the tunnel so that the material under treatment is caught on a conveyor moving below the atomiser in the length direction of the tunnel.

Section XI

Drum-drying of Latex

(1) General Rubber Company
F.M.S. Grant No. 359, 1923

Improved Process and Apparatus for drying coagulable Liquids

A heated cylinder partially immersed in latex, is rotated at such a speed that the film of latex exposed on the upper portion of the drum is dried and is continuously removed and warmed in superimposed layers. The removal of the dried film is effected by a roll suitably placed in contact with the rotating drum. The latex is held in a shallow pan the position of which, relative to the rotating drum, may be adjusted.

Section XII

Coagulation Vessels

(1) General Rubber Company
F.M.S. Grant No. 100, 1917

Improvements in Apparatus for treating Latex

Latex is introduced into a cylindrical steel tank, having a cover which can be fixed and which will resist internal pressure. The

inside of the cover carries a spiral partition which dips into the latex so as to produce a continuous strip of rubber on coagulation. Formers of other shapes may be used. The pressure developed during coagulation, forms the coagulum into a dense strip or into a dense mass of any other desired shape.

(2) Hans Schweizer
F.M.S. Grant No. 695, 1931
Improvements in and relating to Latex coagulating Tanks

Describes the construction of an all-metal tank.

(3) E. H. Kirby
F.M.S. Grant No. 719, 1932
Improvements in and relating to Latex coagulating Tanks—sectional Units

Describes tanks of which the end plates are detachable so that new sections may be introduced at will when it is desired to increase the capacity of the equipment.

Section XIII

Coagulation Processes

(1) General Rubber Company
F.M.S. Grant No. 103, 1917
Improvements in Processes of treating Latex and the Products obtained thereby

A collecting vessel is described having a lid adjustable to the amount of latex in the vessel; this prevents churning and occlusion of air. The transport tank at the collecting station may contain an amount of stabilizer or disinfectant to give 0.2 per cent. beta naphthol, 0.1 per cent. sodium fluoride, 0.5 per cent. pine tar creosote in sodium cresylate, or 0.1 per cent. hexamethylenetetramine calculated on the latex. Coagulation is carried out in a vessel which is completely full of latex and which is pressure tight. The pressure set up during coagulation, produces a tough close-grained rubber.

(2) General Rubber Company
F.M.S. Grant No. 111, 1917
Improvements in Rubber Coagulum or similar Material and the Process for Preparation of the same from Latex for Vulcanisation

In order to produce a coagulum containing the nitrogenous and other constituents of latex and at the same time free from the tendency to develop a slimy surface, one third of one per cent. of boric acid is added to the latex before coagulation. A variety of protein precipitants may replace boric acid for the purpose.

(3) H. W. Hammond
British Patent No. 236,633
Application date April 8, 1924
Complete accepted July 8, 1925
Registered in F.M.S. No. 7, 1924
Process for the Coagulation of Rubber Latex

Latex is coagulated by boiling it with a saccharine solution. The saccharine solution may preferably be obtained from cane sugar molasses. Boiling may be carried out at 212°F by means of steam at 15 lbs. per square inch. Greater tensile strength and better ageing properties are claimed for the rubber so prepared.

(4) J. Y. Johnson from I.G. Farbenindustrie A.G.
British Patent No. 300,719
Application date Aug. 27, 1927
„ „ Sept. 15, 1927
Complete accepted Nov. 22, 1928
Registered in F.M.S. No. 68, 1927
Improvements in the Production of raw Rubber from Rubber Latex

Latex is coagulated by the addition of proteases, preferably that from *Succus Carica papaya* in the presence of an activator such as hydrogen sulphide or hydrocyanic acid. Coagulation can be accelerated or retarded by suitably adjusting the acidity or alkalinity of the latex. Ammoniated latex may be coagulated in this way if the ammonia is first removed by an air blast or by neutralization.

(5) J. Y. Johnson from I. G. Farbenindustrie A.G.
British Patent No. 309,245
Application date Jan. 23, 1928
„ „ Jan. 27, 1928
Complete accepted April 11, 1929
Registered in F.M.S. No. 72, 1928

Improvements in the Production of Rubber from Rubber Latex

Latex is treated with substances such as sulphonic acids or Turkey red oils, which reduce surface tension and is then brought quickly to an acidity of pH 1-2 by means of an acid or a substance which produces acid. The sodium salts of isopropyl napthalenesulphonic acid and butyl napthalenesulphonic acid are mentioned and these are added in 5 per cent. solution at the rate of 60-80 ccs. per litre of 12-18 per cent. D.R.C. latex.

Section XIV

MACHINERY FOR THE TREATMENT OF RUBBER

(1) E. L. Walker
F.M.S. Grant No. 283, 1922
Improvements in Machinery for cutting Rubber or similar Material

The apparatus consists of spiked or toothed discs attached to a pair of rotary shears.

(2) Huttenbach Lazarus & Sons Ltd. (J. L. Milne)
British Patent No. 383,062
Application date Nov. 13, 1931
Complete accepted Nov. 10, 1932
Registered in F.M.S. No. 148, 1933
Improvements relating to the Manufacture of Rubber Sheet from coagulated Latex

A battery of sheeting machines designed to handle a continuous coagulum. The number of revolutions per unit time is the same for all rolls; different peripheral speeds are provided by employing at successive stages, pairs of rolls of different diameters. The following figures are given :—

		Diameter inches	Surface Speed at 40 ft. per minute
First Rolls	...	$5\frac{3}{4}$	60
Second Rolls	...	$6\frac{1}{8}$	64
Third Rolls	...	$6\frac{3}{4}$	70
Fourth Rolls	...	7	73
Fifth Rolls	...	$7\frac{1}{4}$	76
Marking Rolls	...	6	63

Each pair of rolls is coupled by toothed wheels and all rolls are caused to revolve at the same speed by worm wheels and worms on a single shaft.

(3) E. W. Savege
F.M.S. Grant No. 712, 1932
Improvements in and relating to Machines for rolling coagulated Latex and like Materials

A rolling machine in which three rolls are arranged to give two rolling surfaces. One or more rolls operate in eccentric bearings which, when rotated, adjust the clearances between rolls.

Section XV

VULCANISATION OF RUBBER

(1) S. J. Peachey
F.M.S. Grant No. 223, 1930
Process for the Vulcanisation of Caoutchouc

Rubber is vulcanised without the action of heat, by alternate exposure to atmospheres of sulphur dioxide and hydrogen sulphide. Rubber dissolved in a solvent may be vulcanised by partially saturating the solution with hydrogen sulphide and subsequently adding a solution of sulphur dioxide.

(2) S. J. Peachey
F.M.S. Grant No. 247, 1921
Process for the Vulcanisation of Caoutchouc

Rubber or its solutions are vulcanised without the aid of heat, by alternate treatment with sulphur dioxide and hydrogen sulphide at pressures above atmospheric.

(3) Naugatuck Chemical Company
F.M.S. Grant No. 628, 1929
Treatment of Rubber and Products obtained thereby

In order to produce a rubber possessing improved flexing properties, thymol derivatives, such as nitroso or aminothymols, are incorporated in the mix or they may be added to latex before spray drying. Alpha or beta napthoquinone may also be used. Flexing may be improved by 300 per cent.

Section XVI

RUBBER ROADWAYS MATERIALS

(1) R. St. George Caulfield
F.M.S. Grant No. 241, 1921
Improvements relating to a Method of affixing Rubber to Paving Blocks

Paving blocks having an upper cap of rubber, secured to a concrete base by means of an intermediate layer of expanded metal which is partly embedded in the concrete and partly in the upper layer of rubber.

(2) W. F. Barns
F.M.S. Grant No. 261, 1922
Barns reinforced Rubber Road and Traffic Surface

Describes a system of uniting road blocks to their neighbours. The blocks are holed and are held together by lengths of wood or metal passing through the holes.

(3) L. Cresson
F.M.S. Grant No. 558, 1928
Improvements in or relating to composite Rubber-faced surfacing Material

Describes methods for the manufacture of composite blocks having a cement base, a soft rubber cap and thin intermediate layer of hard rubber. The intermediate layer of hard rubber may be formed in situ by treating the cement or the rubber facing with rubber solutions or latex compounds which contain a sufficiently high percentage of sulphur to yield a hard rubber when vulcanised. The cement base may contain fibrous matter. The facing may contain silicate reacting materials.

(4) G. P. Davis
F.M.S. Grant No. 699, 1931
Improvements relating to Roadmaking

Latex, rubber solutions or other vulcanisable substances, are treated with compounding materials common in trade mixes. Two per cent. or more of sulphur and preferably three per cent. of zinc oxide are included, together with sufficient of a two per cent. solution of chlorophyll to give 0.5 per cent. chlorophyll by weight. The mix is laid on a suitable foundation which may be treated with a waterproofing material. The chlorophyll is stated to accelerate and activate all vulcanising agents present and to bring about solar vulcanisation, the surface being ready for traffic in from 2 to 7 days. The cracks which form during drying may be filled with a vulcanising solution.

Section XVII

PREPARATION OF SOFT RUBBER

(1) R. M. Ungar and P. Schidrowitz
F.M.S. Grant No. 718, 1932
A Process of Manufacture of softened Rubber

Rubber, preferably disintegrated, is heated to a temperature of 340°—345°F. From this stage, heating may be continued in vacuo for about two hours. The rubber may then be re-heated in air for a further period of approximately three quarters of an hour, before being removed and exposed to freely circulating air. The rubber increases in weight by 0.5-0.2 per cent. by absorption of oxygen. The product is soft and does not recover "nerve" before vulcanisation.

Section XVIII

PREPARATION OF OIL FROM RUBBER

(1) M. Kelway Bamber
F.M.S. Grant No. 411, 1924

A Process for the Manufacture of crude Dipentene from crude Rubber and for the Recovery of liquid Rubber

Raw rubber, preferably scrap, is subjected to dry distillation. The distillate which is obtained between 170°C and 300°C is taken as crude dipentene. Still and condenser pressures are arranged so as to obtain a yield of 40—45 per cent. crude dipentene, leaving a still residue equal to 50 per cent. of the original rubber. Details are given of the manner of heating the still. Uncondensed gases may be returned for use as fuel to the furnace.

(2) David Graham
F.M.S. Grant No. 556, 1928

Rubber Oil anti-malarial Mixture

Scrap rubber is subjected to dry distillation. The distillate is collected up to 270°C. In the oil so obtained, rubber is dissolved at the rate of 1 oz. per 100 fluid ounces of oil. The product is used as an anti-malarial mixture.